MicroComputer JOURNAL

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May/June 1994

Pen-Based Computing: Is It In Your Future?

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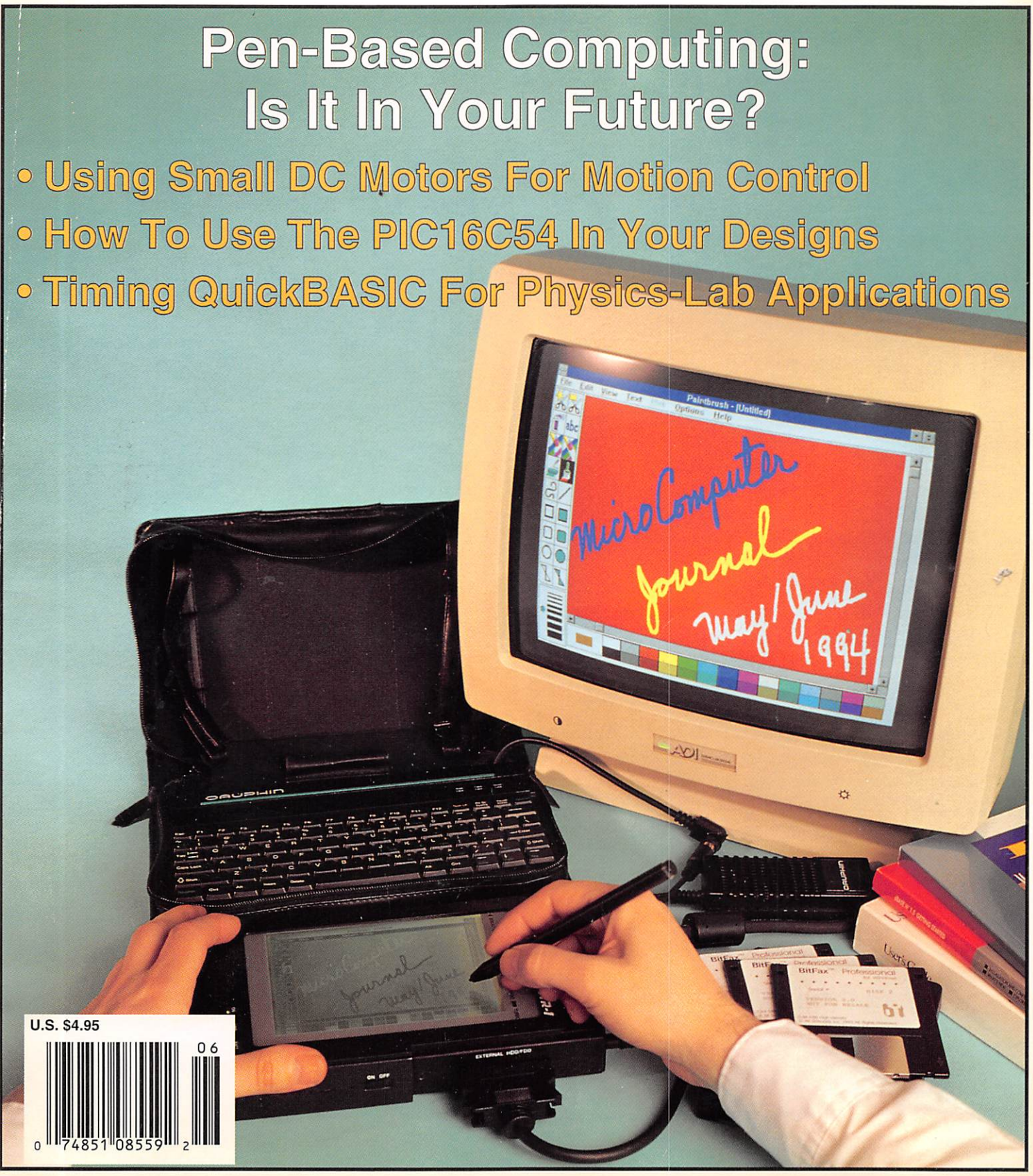
- Timing QuickBASIC For Physics-Lab Applications



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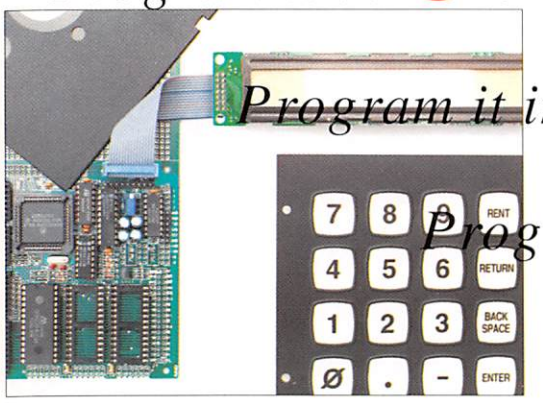

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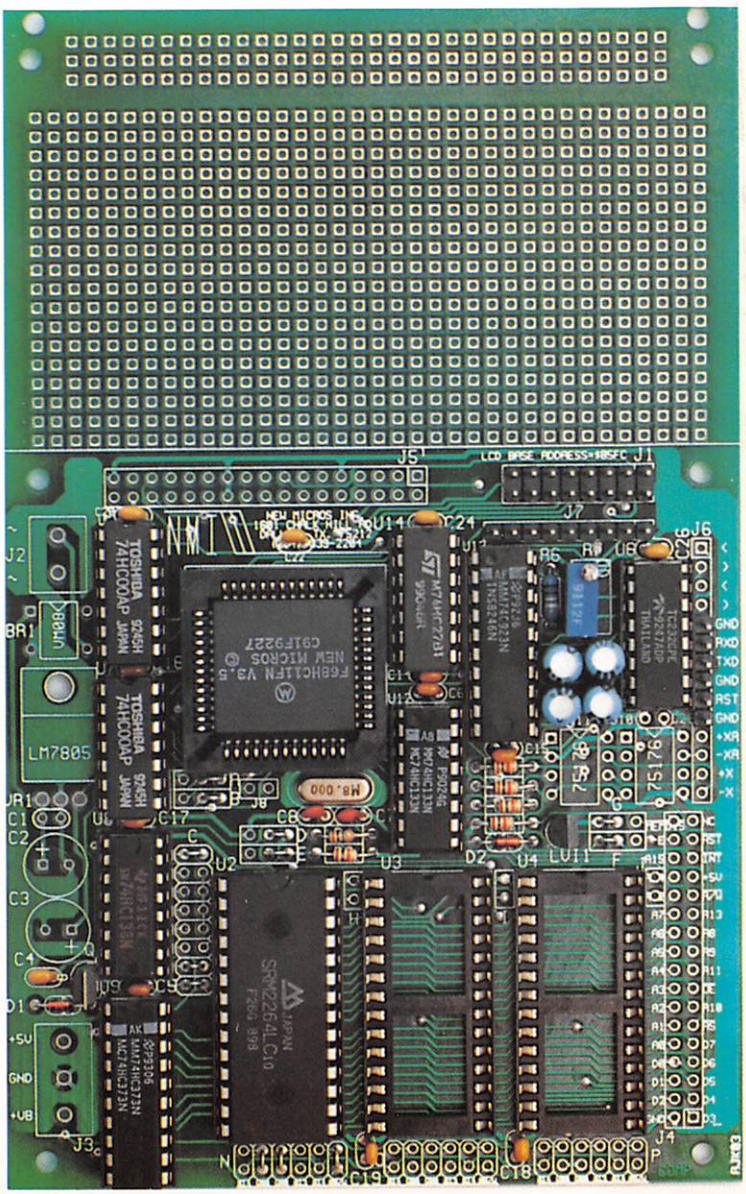

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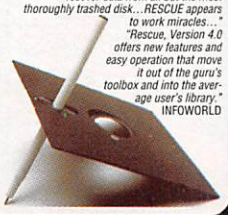

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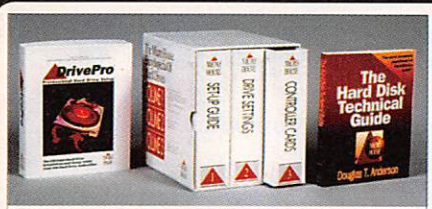

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PC MAGAZINE EDITORS' CHOICE July 1993

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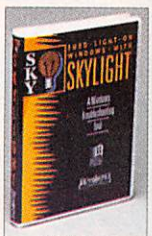

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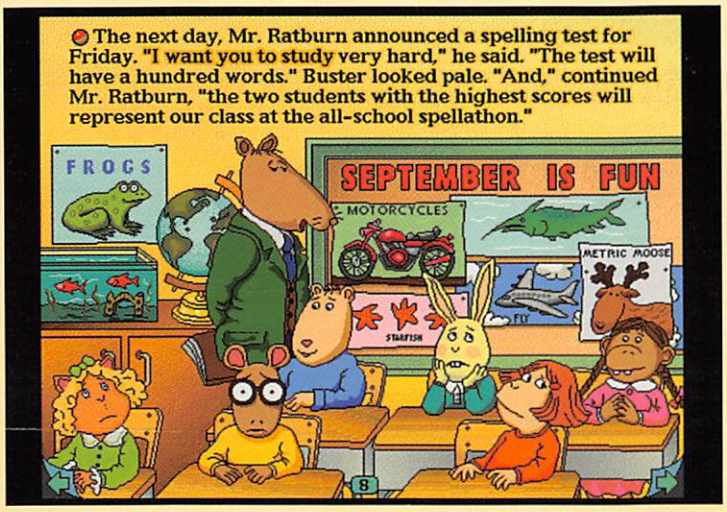
MicroComputer JOURNAL

Volume 1, No. 3, May/June 1994



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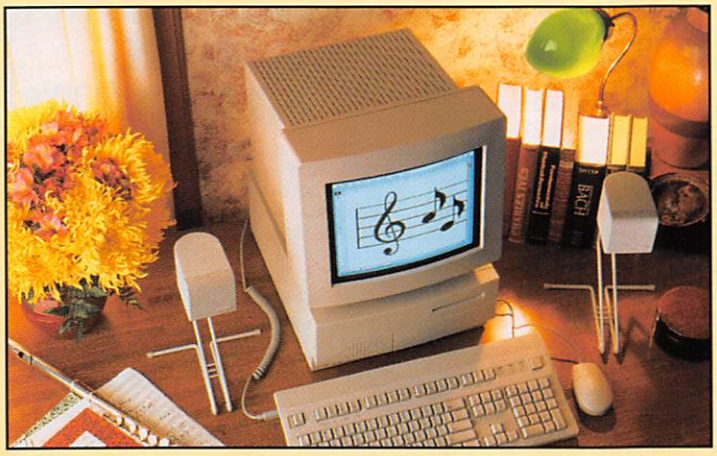

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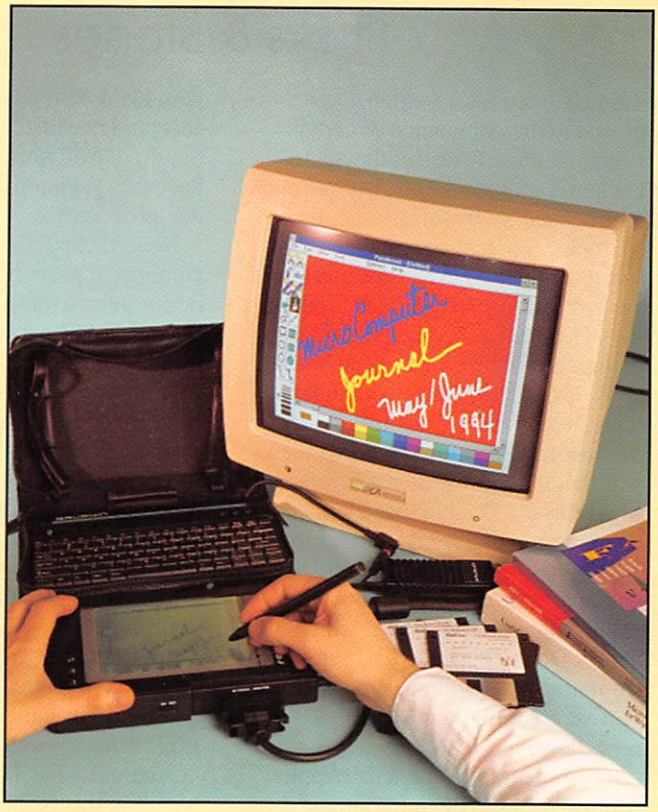

In This Issue

This month's cover provides a glimpse into one of the technologies being heavily explored for more-traditional human input to a computer: writing (or, more accurately, printing) by hand. The computer shown is Dauphin's pen-based DTR-1 desktop replacement PC built around a 25-MHz 486 CPU and LCD viewing screen. For a hands-on review of this little gem, see the evaluation beginning on page 80.

Next, turn to page 86 to read about tiny on-the-road, take-anywhere power subnotebook computers from Hewlett Packard and Epson. Joe Desposito lived for several months with these two units and offers his hands-on comments and muses about where the mini-PC is heading.

Finally, turn to GUI Guts beginning on page 103 to get the inside track on IBM's efforts to bring an even more-natural human-input scheme—vocal communication to the PC and a hardware/software package from Verbex Voice Systems that lets you get started with this technology on your PC.

Cover Photo By Lorinda Sullivan

MicroComputer Journal on MCI Mail

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Editorial By Art Salsberg

Sticks & Stones

There's been a lot written about threats to the dominance of certain companies and forces in the microcomputer industry. Antitrust murmurings against Microsoft persist, for example. A patent-infringement lawsuit recently won ($120-million) against Microsoft by STAC Electronics was heavily cheered on TV, although the decision will be appealed, and a lesser trade-secret suit against STAC was won ($13.7-million) by Microsoft. Unmentioned on TV news was that the jury verdict was related to MS-DOS 6's DoubleSpace software-compression utility and that it killed Vertisoft's stand-alone *DoubleDisk* and *Space Manager* products. As a result, Microsoft DOS 6.1, which includes DoubleSpace, will disappear from new MS-DOS packages. (If you've got it on your MS-DOS disk now, however, it's okay to use.)

The potential of the IBM/Apple/Motorola PowerPC microprocessor to dethrone Intel's Pentium has been trumpeted recently, too. "Finally, you have a choice!" is the typical headline on articles in the PC press regarding the PowerPC chip. It's faster, lower priced...blah, blah, blah. And it does *Windows* (through emulation), too.

The PowerPC challenger, a RISC processor, has one advantage that other RISC processors don't have: it can be inexpensively manufactured. Indeed, it's much cheaper to produce than the dominant CISC processors that are ingrained in some 95% of desktop PCs today. It's also smaller, runs cooler because it requires much less current, it can run a bunch of ported operating systems, including Apple Macintosh System 7, *Windows NT*, OS/2, and so on. The rub is that it has zero shrink-wrapped applications. It won't remain zilch, of course. But it's got a long way to go to match what an Intel Pentium, 486 and so on have in terms of applications software at this time. Moreover, running, say, *Windows* in emulated form slows things down, which is an important negative, considering that *Windows* is already slow enough as it is.

On top of the foregoing is user inertia in willingness to learn a new system, whether it's Unix or what-have-you. Hardware advances are readily accepted because no learning curve is required. Software, on the other hand, becomes yet another educational hurdle to overcome.

Nevertheless, there are severe shortcomings at present for serious CAD, desktop publishing and multimedia operations. The move to advanced 32-bit operating systems and more-powerful microprocessors will clearly have to be made for those who will get a business benefit (spell benefit as "profit") from it. For the rest of us, it'll be a long time coming before such a major switch is made, I believe. And Intel won't be standing still as the PowerPC alliance trains its guns on this current microprocessor giant.

Another thrust in the microcomputer field is use of a notebook computer as a desktop machine (see the Dauphin DTR-1 review and Joe Desposito's "Computing On The Go" column elsewhere in this issue for details on three miniature PCs that go this route). Although this can be and is being done, the shortcomings of doing so should be fairly obvious: less-efficient keyboard, smaller memory capacity, limited (if any) expansion slots, etc. In effect, if you use a portable PC in place of a desktop unit, it's like using a sports car as your family car. You can do it, but at times its failings are inescapable. As a result, full- blown desktop PCs won't disappear soon, regardless of all the ballyhoo.

Lots of words have been and will continue to be spewed out about revolutionary new products and dominant companies soon to take a big hit. As for me, I'm not about to make any truly major switches in my PC life until the dust settles a bit. Adding a much-larger-capacity hard drive, a color scanner, perhaps a quadruple-speed CD-ROM drive and the like are more probably the movements I'll make at this time, rather than virtually starting over again with a new kind of computer and operating system—at least for personal use. At the business end, though, we'll be closely watching how the marketplace develops.

Art Salsberg

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TECHNOLOGY UPDATE

900 MHz breakthrough!

New technology launches wireless speaker revolution...

Recoton develops breakthrough technology which transmits stereo sound through walls, ceilings and floors up to 150 feet.

Breakthrough wireless speaker design blankets your home with music.

By Charles Anton

If you had to name just one new product "the most innovative of the year," what would you choose? Well, at the recent *International Consumer Electronics Show*, critics gave Recoton's new wireless stereo speaker system the *Design and Engineering Award* for being the "most innovative and outstanding new product."

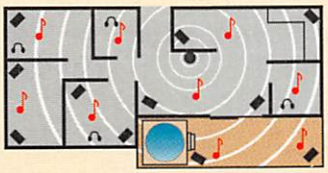
Recoton was able to introduce this whole new generation of powerful wireless speakers due to the advent of 900 MHz technology. This newly approved breakthrough enables Recoton's wireless speakers to rival the sound of expensive wired speakers.

Recently approved technology. In June of 1989, the *Federal Communications Commission* allocated a band of radio frequencies stretching from 902 to 928 MHz for wireless, in-home product applications. Recoton, one of the world's leading wireless speaker manufacturers, took advantage of the FCC ruling by creating and introducing a new speaker system that utilizes the recently approved frequency band to transmit clearer, stronger stereo signals throughout your home.

150 foot range through walls!

Recoton gives you the freedom to listen to music wherever you want. Your music is no longer limited to the room your stereo is in. With the wireless headphones you can listen to your TV, stereo or CD player while you move freely between rooms, exercise or do other activities. And unlike infrared headphones, you don't have to be in a line-of-sight with the transmitter, giving you a full 150 foot range.

The headphones and speakers have their own built-in receiver, so no wires are needed between you and your stereo. One transmitter operates an unlimited number of speakers and headphones.



Recoton's transmitter sends music through walls to wireless speakers over a 75,000 square foot area.

Crisp sound throughout your home. Just imagine being able to listen to your stereo, TV, VCR or CD player in any room of your home without having to run miles of speaker wire. Plus, you'll never have to worry about range because the new 900 MHz technology allows stereo signals to travel over distances of 150 feet or more through walls, ceilings and floors without losing sound quality.

One transmitter, unlimited receivers. The powerful transmitter plugs into a headphone, audio-out or tape-out jack on your stereo or TV component, transmitting music wirelessly to your speakers or headphones. The speakers plug into an outlet. The one transmitter can broadcast to an unlimited number of stereo speakers and headphones. And since each speaker contains its own built in receiver/amplifier, there are no wires running from the stereo to the speakers.

Full dynamic range. The speaker, mounted in a bookshelf-sized acoustically constructed cabinet, provides a two-way bass reflex design for individual bass boost control. Full dynamic range is achieved by the use of a 2" tweeter and 4" woofer. Plus, automatic digital lock-in tuning guarantees optimum reception and eliminates drift. The new technology provides static-free, interference-free sound in virtually any environment. These speakers are also self-amplified; they can't be blown out no matter what your stereo's wattage.

Stereo or hi-fi, you decide. These speakers have the option of either stereo or hi-fi sound. You can use two speakers, one set on right channel and the other on left, for full stereo separation. Or, if you just want an extra speaker in another room, set it on mono and listen to both channels on one speaker. Mono combines both left and right channels for hi-fi sound. This option lets you put a pair of speakers in the den and get full stereo separation or put one speaker in the kitchen and get complete hi-fi sound.

These wireless stereo headphones have a built-in receiver.

Factory direct savings. Our commitment to quality and factory direct pricing allows us to sell more wireless speakers than anyone! For this reason, you can get these speakers far below retail with our 30 day *"Dare to Compare"* money-back guarantee and full one year manufacturer's warranty. For a limited time, the Recoton transmitter is only $69. It will operate an unlimited number of wireless speakers priced at $89 and wireless headphones at $59 each. Your order will be processed in 72 hours and shipped UPS.

Recoton Transmitter (you must have a transmitter to operate speakers and headphones).....**$69** $4 S&H

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AWARD WINNING WIRELESS SPEAKER

Built-in receiver and amplifier:

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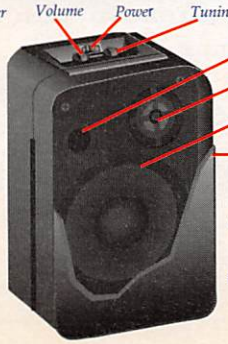


Size: 9"H x 6"W x 5.5"L
Signal-to-noise ratio: 60 dB
Channel Separation: 30 dB
Two-way bass reflex design
10 watts/channel RMS amps
Frequency Response: 50 Hz-15 KHz

Don't take our word for it. Try it yourself. We're so sure you'll love the new award-winning Recoton wireless speaker system that we offer you the **Dare to Compare Speaker Challenge.** Compare Recoton's rich sound quality to that of any $200 wired speaker. If you're not completely convinced that these wireless speakers offer the same outstanding sound quality as wired speakers, simply return them within 30 days for a full "No Questions Asked" refund.

Recoton's Design and Engineering Award

SALVAGING OLD MEMORY. Autotime Corp. (Tel.: 503-452-8577) announced a circuit-board configuration that permits a way to salvage a computer's old memory while upgrading memory. The conversion board allows building of a 1M memory SIMM module from old 256K chips or build a 4M SIMM module from old 1M memory chips. A customized logic chip (PAL) is used for memory decoding.

CD-ROM HAPPENINGS. A 500M multimedia clip library—Q/Media for Windows CD-ROM version—was introduced by Q/Media Software (Tel.: 604- 879-1190). Combined with Tri-Digital Software's DigiClips special edition, it offers a mix of the entire multimedia gamut of digital video, voice, animation, music, sound tracks, backgrounds and graphic images. Also, without programming, scripting or conversion, it's said that users can very simply bring files created in other software—such as CorelDRAW drawings, Harvard Graphics charts or Freelance slides—into Q/Media for Windows. Retail price is $149.

Kodak plans to produce smaller-format CD-ROM drives that use an 80-mm disc format to complement the company's original 120-mm Photo CD discs. The system is aimed at future notebooks, laptops and PDAs. Discs will be the size of audio CD singles and will be backward-compatible with nearly all players and CD-ROM drives that can read or write current Photo CD discs. (A small cavity built into 120-mm drives will hold the 80-mm disc while it plays. The 80-mm discs have one-third the data-carrying capacity of 120-mm discs.

Programmer's Shop (Tel.: 617-740-0101) introduced CD SELECT, a series of CD-ROM discs that contain software targeted at PC professionals and programmers. The first disc includes development tools from Microsoft and related tools from other makers and personal productivity applications from Cognos, Halcyon, Micrografx and Traveling Software. CD SELECT allows users to "test drive" these software products, then purchase them by calling The Programmer's Shop to receive an access code that enables them to unlock encrypted software and install it on their hard drives....Apple Computer also has a convenient way for computer users to explore and purchase independent vendors' software for Windows PCs and Macintosh computers, called Software Dispatch. This CD-ROM delivery system operates seven days per week, 24 hours per day. To receive a free Software Dispatch CD-ROM, call 1-800-937-2828, Ext. 600.

MULTIMEDIA SOFTWARE AT THE HOLOCAUST MUSEUM. The Learning Center at the Washington, DC museum uses 20 MS-DOS-based IBM 66-MHz 486 PCs with Intel ActionMedia II cards Each PC includes three sets of headphones and a 20" VGA video monitor to provide interactive, simultaneous video and graphics to users. Using Protocomm Multimedia software, video files are centrally located on Novell file servers. Workstation video monitors use touch screens that permit selection of six data types: audio, digital still photos, text, graphics, animated graphics or full-motion video at 30 frames per second. The museum's database contains an encyclopedia of the Holocaust and a chronology of daily events from 1933 to 1949. Each visitor to the museum is given an ID number that can be used to look up details about a person who experienced the Holocaust and who might be the same age and gender of the visitor.

WINDOWS FOR THE BLIND. Windows Master, a software package from Blazie Engineering (Tel.: 410-893-9333) is reported to give blind and visually-impaired computer users access to all popular Windows applications enjoyed by sighted counterparts. It combines with the Braille 'n Speak Personal Data Assistant to provide the efficiency of Grade II Braille input.

Where's the Beta?

• I've been reading your magazines for years and found them to be enoyable and informative. Got worried with the last issue of *MicroComputer Journal* when your "GUI Guts" columnist, Yacco, wrote that all developers working with the beta version of "Chicago" or *Windows* 4.0 were raving about it, and you mentioned the beta version in your editorial. It hasn't been out yet?

Marc Salzberg

It should have been called the "pre-beta" version, which has been in the hands of developers since September 1993, I'm told.—Ed.

On-Site Warranty Problem

• In September of last year, I purchased a Leading Edge computer with a 12-month on-site warranty. In December, I realized that the computer required service. The warranty registration certificate instructs users to call 800-245-9870 for service. I've called this number more than 10 times, and each time I received a recorded message saying all lines are busy and telling me to call back later.

When I became frustrated with the 800 number, I called Leading Edge's headquarters in Westboro, MA for assistance. The Warranty Administrator to whom I spoke insisted that calling the 800 number was the only way to obtain warranty service. I then phoned and wrote to the Manager of Customer Service. She has not replied. I even wrote to Michael Morand, president of Leading Edge. He has not replied, either. It's now been many weeks of trying to communicate with Leading Edge. Still trying.

Paul Konigstein
New York, NY

I tried the 800 number a few times and got the same busy message. I think a law of physics is involved somewhere that states that there are never enough customer-service reps to handle toll-free 800 lines. It's indeed frustrating.—Ed.

Clone Builder

• I've just encountered your magazine for the first time and I've been truly surprised to find a magazine that deals directly with the technical information instead of just spouting undefined acronyms and buzzwords. I'm subscribing to your magazine so that I may eventually acquire definitions of the many obscure words I've heard in the PC industry. I also hope to learn what the true attributes of these words are.

More importantly, however, is that I'm in the process of trying to put together an IBM clone for myself. About three years ago, I bought a 386/33 IBM clone from a store that built finished systems for its customers. I never liked the result and I'm just beginning to find out some of the reasons why. Building a PC on your own is no easy task because those knowledgeable in hardware aren't willing to give out information, and those willing to give out information usually aren't knowledgeable.

Arthur Goeres
Portland, OR

Corrections

• In "The *Real* Cost of Upgrading to *Windows* 3.1" (March/April) on page 74 under Sources, the name of the organization for the item identified by "Circle No. 145..." should read Multimedia PC Marketing Council.

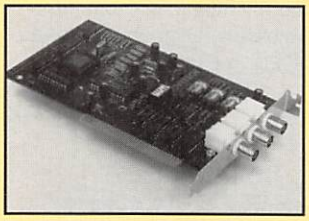
• The bulletin-board telephone number given for R4 Systems in the ad on page 40 of January/February issue was incorrect. The correct number is 905-898-0508.

• Tables 3 and 4 in "PCMCIA: Panacea or Pandemonium?" (March/Apr) were accidentally omitted from the published article. These tables are on page 110.

Hardware

Digital-Synthesizer Card

Novatech Instruments' DDS3 PC 12-MHz synthesized signal source add-in card for IBM PC and compatible computers can



generate sine-wave and TTL/HCMOS clock signals simultaneously over a frequency range of 2 Hz to 12 MHz in 2-Hz steps. Phase noise is rated to be less than –90 dBc at 1 kHz offset, spurious signals at below –45 dBc, and harmonics at less than –40 dBc. Output amplitude is 12 volts peak-to-peak into an open circuit and can be attenuated in 10-dB steps to –70 dB.

The DDS3 PC comes with a C-language program that runs under DOS. It lets you set frequency and attenuation and sweep through a set of frequency, attenuation and dwell time settings. A driver is available for third-party *Windows*-based ATE programming environments. $399. *Novatech Instruments, Inc., 1530 Eastlake Ave. E., #303, Seattle, WA 98102; tel.: 206-328-6902; fax: 206-328-6904.*

CIRCLE NO. 1 ON FREE CARD

12-Bit Data Acquisition

John Bell's 12-Bit Analog to Digital Converter board is a low-cost 12-bit, eight-channel multiplexed A/D unit for IBM and compatible PCs. It has one eight-bit input TTL port and one eight-bit output TTL port. All I/O is through a 37-pin D-shell connector. A disk with BASIC programs for a low-frequency oscilloscope, data logger and thermometer is included. $149.95. *John Bell, 1381 Saratoga St., Minden, NV 89423; tel.: 702-267-2704.*

CIRCLE NO. 2 ON FREE CARD

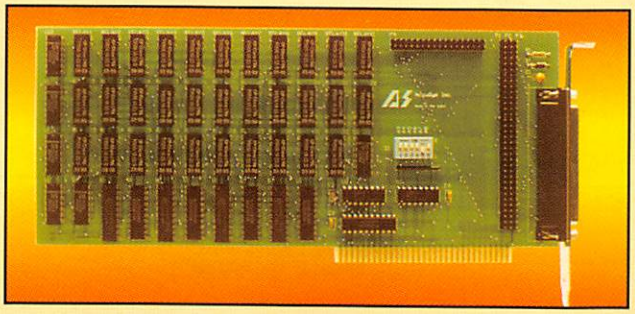
Virus-Protection System

PC Defender from American Megatrends is a new anti-virus protection system that combines virus prevention software with an add-on monitor card. The system includes three protection elements: Scan and Clean software, a Boot Monitor Card and an Illegal Activity Monitoring Module. These three elements are said to identify and clean a virus that's on your system and stop a virus during the process of infection. The system also includes protection of the machine during the critical boot cycle. $119.95. *American Megatrends, 6145-F Northbelt Pkwy., Norcross, GA 30071; tel.: 404-263-8181; fax: 404-263-9381.*

CIRCLE NO. 3 ON FREE CARD

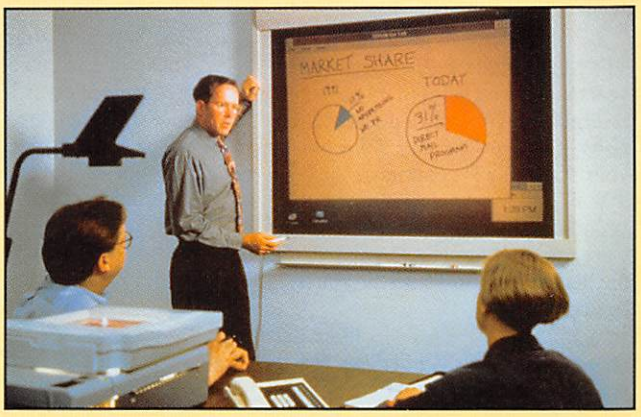
Smart Switching

The 32 Switch Reed Relay Card from AccuSys, Inc. add-in card offers low-power management of analog or digital signals. Relay status can be checked through included software, and conditional and multi-conditional switching combinations can be created by wire wrapping pin headers. $395. *AccuSys, Inc. 3695 Kings Row, Reno, NV 89503; tel.: 702-746-1111; fax: 702-746-2306.*



Smart Switching

CIRCLE NO. 4 ON FREE CARD



Whiteboard For the PC

Whiteboard For the PC

SoftBoard from Microfield Graphics, Inc., combines the functionality of the commonplace whiteboard with the capabilities of desktop computers. Any information written on the SoftBoard surface, using special colored markers, is simultaneously displayed on a PC or Macintosh computer. This data can then be saved, printed or used in other applications, among other things. The whiteboard measures 54" x 60". $2,995. *Microfield Graphics, Inc., 9825 SW Sunshine CT., Beaverton, OR 97005; tel.: 503-626-9393; fax: 503-641-9333.*

CIRCLE NO. 5 ON FREE CARD

Pocket Wireless Fax

Smith Corona's Handifax HF-1000 pocket-sized PDA features wireless fax-send capabilities. Additionally, it offers a digital notepad, scheduler, calendar, phone book and dialer, calculator and clock. A pop-up 9,600-baud acoustic fax coupler and RJ-11 plug-in phone-cable port make it easy to send a fax from any location. You can type messages up to 120 pages in length on the unit's typewriter-style keyboard and view them on its 51-character by five-line LCD screen. *Smith Corona Corp., 65 Locust Ave., New Canaan, CT 06840; tel. 203-972-1471.*

CIRCLE NO. 6 ON FREE CARD

Pocket Wireless Fax

Interesting CD-ROM Software

If you have a CD-ROM drive, you'll almost certainly want to look into a new software title from Virtual Reality Laboratories. *Vistapro* 3.0 is a multimedia extravaganza that takes you into the realm of virtual-reality landscaping.

Vistapro runs under DOS 3.0 or later and *Windows* 3.1, and requires a minimum of a 386 PC, 4M of RAM, VGA video system and a Microsoft-compatible mouse. This package includes *Vistapro*, *MakePath Flight Director* and *VistaMorph* programs, plus landscape files, music tracks and a collection of sample images and animations.

Vistapro is a three-dimensional landscape-simulation program that enables you to recreate and explore landscapes on Earth and Mars in 24-bit color. You can add water features and 3D trees with individually-shaded leaves. *Vistapro* uses fractal texturing to create realistic-looking rock surfaces and lots more. The program also generates left and right images for 3D stereo viewing. This CD-ROM version of the program lets you export landscapes as 3D .DXF objects you can use with Autodesk's *3D Studio* and other 3D ray-tracing programs, allowing you to combine *3D Studio* objects with *Vistapro* landscapes in both single-frame images and animation sequences.

Makepath Flight Director is an animation tool for use with *Vistapro* simplifies creation of "fly-through" animations. You simply choose the type of vehicle—motorcycle, glider, cruise missile, etc.—in which you wish to travel through a landscape and a flight path on any *Vistapro* landscape map. *Makepath* automatically converts your path into a *Vistapro* script you can run from a single menu choice in *Vistapro* to create the animation.

VistaMorph lets you automate creation of Vistapro animations via its point-and-click interface. In conjunction with *Vistapro*, *VistaMorph* creates smooth "morphing" transitions from one landscape to another or from one *Vistapro* setting—tree height, snow line, sun position, etc.—to another. *VistaMorph* lets you do such things as create a scene that changes from winter to spring and from daylight to dusk with lengthening shadows and a sky that changes from blue to red as the sun moves toward sunset.

After creating an animation, you can play it back using either of two included animation players. You can specify a MIDI music file or CD audio track to play as a sound track with the animation.

The CD-ROM comes with 4,690 landscape files that include much of the US at a resolution of 30 meters between data points so that you can zoom in for details; all of the US at a lower level of detail; the entire surface of Mars between 50° south and 50° north latitude; Matterhorn, Switzerland; Mt. Fuji, Japan; and much more.

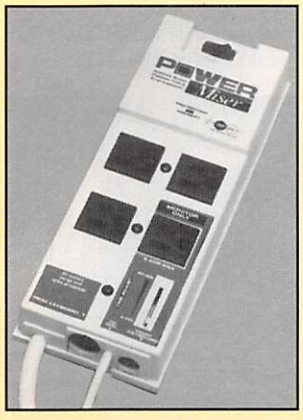
Features in the *Vistapro* package include: high-resolution 24-bit color images; variable focal length "camera" lens, unlimited number of lighting positions, dithering, roughness and blend colors; 3D wire-frame preview; the ability to add lakes and rivers to any landscape; user-defined color palette, night sky, stars, tree line, snow level, waves, haze levels; 3D trees, including oak, pine, palm and cactus; fractalized clouds; generation and merging of left and right images for 3D stereo viewing; exporting of landscapes in .DXF format; and Autodesk .FLC support. Additionally, the program supports *Windows* 24-bit .BMP, Targa 24 and .PCX image formats. It runs in 386 protected mode.

Vistapro 3.0, $149.95. *Virtual Reality Laboratories, Inc., 2341 Ganador CT., San Luis Obispo, CA 93401; tel.: 1-805-545-8515; fax: 1-805-781-2259.*

CIRCLE NO. 7 ON FREE CARD

PC Power Miser

Tripp Lite's Power Miser combination screen monitor and surge suppresser saves electricity by automatically shutting off computer monitors. Keyboard activity instantly restores the monitor to its prior screen. Monitor shut-off time is adjustable between 5 and 60 minutes via a slide switch. Power Miser is also a four-outlet surge suppresser with spike and line-noise filtering for connected equipment. The unit provides 720 joules of surge suppression and features rfi and emi noise rejection. $99.95. *Tripp Lite, 500 N. Orleans Ave., Chicago, IL 60610; tel.: 312-329-1777; fax: 312-644-6505.*



CIRCLE NO. 8 ON FREE CARD

Mwave Multimedia Card

The ACE Advanced Communication Enhancement system from Best Data Products, Inc., is an internal card for PCs and compatibles that merges fax, modem, sound and telephone-answering capabilities and a CD-ROM interface. This is made possible by a new DSP technology from IBM called Mwave. ACE includes a 14,400/9,600-bps modem/fax, a 16-bit audio card with wavetable synthesis and a Panasonic CD-ROM interface. ACE is said to be fully software-upgrade-able, making it possible to add new applications, such as V.FAST, color faxing and video teleconferencing, as these technologies become available. $259. *Best Data Products, Inc., 21800 Nordhoff St., Chatsworth, CA 91311; tel.: 818-773-9600; fax: 818-773-9619.*

CIRCLE NO. 9 ON FREE CARD

Lightweight Cellular Adapters

Data Race's RediCELL family of cellular-telephone data adapters are ultra-lightweight

Fractal Creations, Second Edition

By Tim Wegner & Bert Tyler
(*Waite Group Press. Soft cover. 470 pages. Includes CD-ROM, 3½" floppy disk and 3D viewing glasses. $34.95.*)
This second-edition book/CD-ROM/floppy-disk package has been updated to include more than 1,800 fractal images, a more-powerful version of the *Fractint* program and a section filled with full-color photos. Additionally, the CD-ROM includes an *Fdesign* fractal-generation program for creating intricate patterns of color and texture that imitate natural shapes like trees, mountains, water, etc.

With this package, you can generate any of the 99 built-in fractal types in full color. You can zoom in on any part of a fractal image, rotate it, recolor it and make it color-cycle so that it seems to move and rotate on your video screen in an unending combination of colors. You can also create a three-dimensional stereo version of your fractals (and view them in stunning 3D stereo vision with the included 3D glasses) or magnify an area to full-screen and then reveal new and strange patterns as you explore the fractal landscape. With *Fractint*, you can create dozens of fractals, tweaking parameters, altering color palettes and shifting color ranges. On the CD-ROM is the complete *Fractint* source code that contains full details of high-performance video, four-dimensional math and full details of how each of the built-in fractal images are created.

Fractint includes 25 new image types, new fractal image effects like orbiting, plotting and 4D crystals and hypertext on-line help. *Fdesign* lets you program and create natural patterns and visually edit IFS equations so that you can instantly see the effect.

The *Fractal Creations* book is as interesting and fascinating at the software and imagery on the CD-ROM. The first three chapters step you through installation of the software, give you a primer on fractals and provide you with a hands-on *Fractint* tutorial to get you up to speed using the software. The next three chapters hone what you've learned by providing fractal recipes, a *Fractint* reference and a tour of fractal types. Chapter 7 takes you into the realm of making IFS fractals with *Fdesign*, while Chapter 8 steps you through the nuances of the *Fractint* source code. Three appendices round out the book: Fractint and Video Adapters, Fractint and GIF Files and Complex and Hypercomplex Numbers.

Throughout, this easy-read book is profusely illustrated with black-and-white photos of fascinating imagery, tables, drawings and examples of code. The 60 fractal-images spread over 16 pages of coated paper are virtually mind-blowing in their color, designs and almost hypnotic effect. If you're into fractals, you need this book/disk package. If you're new to fractals, this package is almost guaranteed hook you!

adapter cords that enable the Data Race PCMCIA 2.0 RediCARD fax/modem to transmit and receive data and fax information over the cellular telephone network. RediCELL adapter cords are available for AT&T 3710/3730, OKI 900/910, NEC P200/300, Motorola DCP55 Flip/Ultra Lite and Pioneer PCC-700/900 cellular phones. RediCELL utilizes a 3-foot-long cord that plugs into a cellular telephone on one end and the PCMCIA card on the other end. $199. *Data Race, 11550 IH-10 West, Ste. 395, San Antonio, TX 78230; tel.: 210-558-1900; fax: 210-558-1929.*

CIRCLE NO. 10 ON FREE CARD

Power-Saving Video Monitor

Optiquest's 2000DC 15" flat, square high-resolution video monitor has built into it a power-saving feature. It powers down in three stages, meets the EPA's Energy Star guidelines and is VESA DPMS-compliant. Also included is a color-management system that lets you adjust each electron gun independently. You can match colors to printed output or standard color schemes and to other monitors.

With a horizontal scan rate of 30 to 65 kHz, the 0.27-mm dot pitch monitor supports res-

olutions up to 1, 280 X 1,024 noninterlaced. The 2000C displays 1,024 X 768 at a flicker-free 60-Hz refresh rate. ARAG coating, microprocessor-based memory, edge-to-edge display and front-access digital controls are additional features. $469. *Optiquest, Inc., 20490 Business Pkwy., Walnut, CA 91789; tel.: 909-468-3750; fax: 909-468-3770.*

CIRCLE NO. 11 ON FREE CARD

"Green" 17" Video Monitor

ViewSonic's Model 17G energy efficient 17" video monitor is equipped with an easy-to-operate on-screen programming system. It powers down in three stages, conforms to the VESA DPMS standard and supports the EPA's Energy Star program. Time to activate each of the stages—standby, suspended and off—is user-programmable. Included is power-management software that interfaces with most video cards.

On-screen programming lets

you adjust up to 13 different controls at the touch of a button, including a ViewMatch color control system that adjusts screen colors to match printer output.

The 17G features 0.28-mm dot pitch, maximum noninterlaced resolution of 1,280 X 1,024 and 76 Hz refresh at 1,024 X 768. Other noteworthy features are ARAG coating and a flat, square screen with an edge-to-edge display. It carries a Swedish MPR-II certification for low radiation emissions and meets the ISO-9241-3 VESA standard. $999. *ViewSonic, 20480 Business Pkwy., Walnut, CA 91789; tel.: 909-869-7976; fax: 909-869-7958.*

CIRCLE NO. 12 ON FREE CARD

Keyboard-Controlled Monitors

Nissei Sangyo America's SuperScan Elite 21, Elite 17 and 15S digitally controlled, multiscanning monitors let you make adjustments from your computer keyboard and store settings for future use with the same application. Adjustments include color temperature, horizontal and vertical size and

width, brightness, contrast, individual RGB color and pincushion. All three monitors meet power- and screen-saving EPA guidelines and comply with Swedish MPR-II emissions standards.

Elite 21 and Elite 17 have 31 microprocessor-based screen presets that automatically adjust the display for best performance with all graphics standards. Both models also have a flat, square CRT with an Invar mask and ARAG coating. The 21" model has a 0.28-mm dot pitch, the 17" model a 0.26-mm dot pitch. Both monitors can handle up to 1,600 X 1,200 noninterlaced video, with a horizontal frequency of 30 to 82 MHz and a vertical frequency of 55 to 120 Hz.

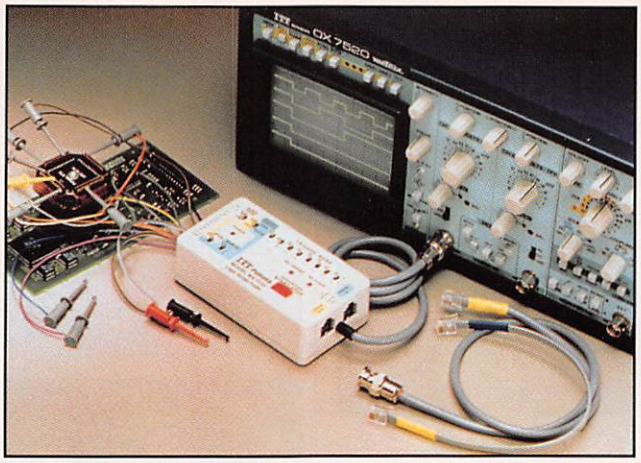
The SuperScan 15S has 21 microprocessor-based screen presets and a 15" flat, square CRT with 0.28-mm dot pitch and anti-glare coating. The 15S can handle up to 1,280 X 1,024 noninterlaced video, with a horizontal frequency of 30 to 64 kHz and a vertical frequency of 50 to 100 Hz. $2,695/$1,495/$549 Elite 21/Elite 17/15S. *Nissei Sangyo America, Ltd., 100 Lowder Brook Dr., Ste. 2400, Westwood, MA 02090; tel.: 617-461-8300.*

CIRCLE NO. 13 ON FREE CARD

Wave-Table Sound Card

SoundMan Wave from Logitech, Inc., is a 16-bit stereo card based on wave-table synthesis. It uses the Yamaha OPL-4 chip and has 44 wavetable and FM voices, full Sound Blaster and AdLib compatibility, 16/8-bit stereo or mono digital audio, 44-kHz sampling, MIDI support, a five-channel stereo mixer and SCSI CD-ROM interface. Included are a variety of software titles, such as MCS *MusicRack*, *Recording Session* and others. $349. *Logitech, Inc., 6505 Kaiser Dr., Fremont, CA 94555; tel.: 510-795-8500; fax: 510-792-8901.*

CIRCLE NO. 14 ON FREE CARD



Digital Analysis For Analog Scopes

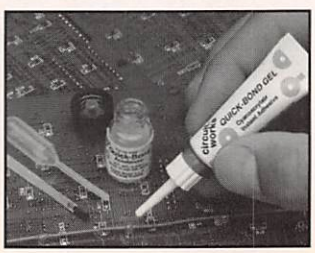
Digital Analysis For Analog Scopes

The MX9100 Logic Scope Probe from ITT Pomona converts an ordinary analog oscilloscope into a logic-analysis instrument that's said to be suitable for examining and analyzing single-shot and repetitive digital signals. This portable, pocket-sized instrument provides an eight-channel reading capability and can be daisy-chained to provide up to 16 or 24 channels. The MX-9100 works with any scope with a bandwidth of 5 MHz or greater, sensitivity of 200 mV/div. and external-triggering capabilities. Grabber-type test leads and BNC scope interface are included. $330. *ITT Pomona, 1500 E. Ninth St., PO. Box 2767, Pomona, CA 91769; tel.: 714-623-3463; fax: 714-629-3317.*

CIRCLE NO. 15 ON FREE CARD

Instant Bonding

Planned Products' 4300 Circuit Works Quick-Bond Gel Kit provides instant bonding of metals, rubbers and plastics. It also contains an accelerator that can be applied directly over the adhesive for instant bonding. Applications include bonding jumper wires to circuit boards, fixturing surface-mount components, component mounting, strain relief and general instant bonding. $6.95. *Planned Products, 303 Potrero St., Ste. 53, Santa Cruz, CA 9506; tel.: 408-459-8088; fax: 408-459-0426.*



CIRCLE NO. 16 ON FREE CARD

VL-IDE Controller

CMD Technology's CSA-6210 VESA VL-Bus true 32-bit IDE Disk Controller supports up to four IDE hard-disk drives and offers compatibility with advanced software features. An exclusive IDE Software Toolkit enables you to tailor an exact configuration for your system. The CSA-6210 is capable of sustained transfer rates up to 8.2 M/sec. $69. *CMD Technology, Inc., 1 Vanderbilt, Irvine, CA 92718; tel.: 714-454-0800.*

CIRCLE NO. 17 ON FREE CARD

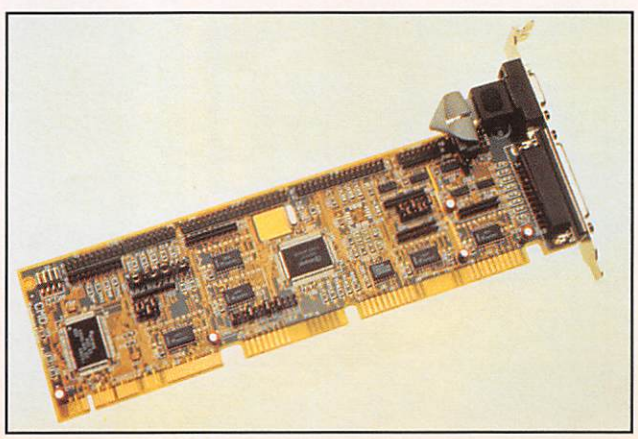
DMM/Oscilloscope Combo

Tektronix's TekMeter series is both a digital multimeter and a 5-MHz oscilloscope in a battery-powered, 2-pound package. The TekMeter THM 550 is a single-channel instrument, the THM 560 is dual-channel and the THM 565 is dual-channel instrument that features a back-lit display and advanced functions.

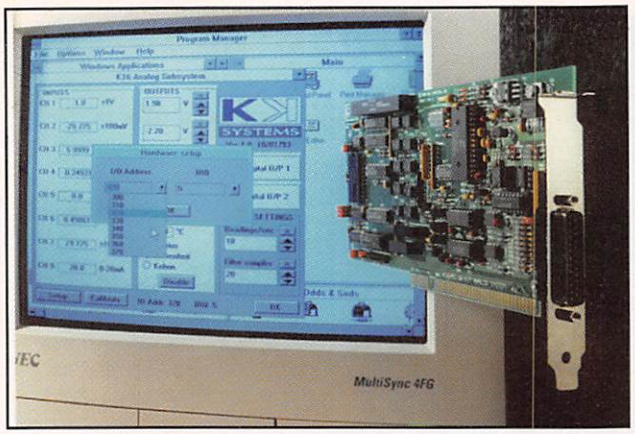
The DMM features autoranging dc and true rms ranges from 400 mV to 600 volts ac/850 volts dc, resistance ranges

from 400 ohms to 40 megohms and diode and audible continuity tests. The autoranging oscilloscope features a proprietary signal-tracking technology that automatically finds, scales and displays signals continuously for hands-free operation. $859/$999/$1,259. 550/560/565. *Tektronix, 14150 S.W. Karl Braun Dr., PO Box 500, Beaverton, OR 97077; tel.: 800-426-2200.*

CIRCLE NO. 18 ON FREE CARD



VL-IDE Controller



Windows Data Acquisition

Windows Data Acquisition

Saelig's K16/PC data-acquisition and control card now includes new datalogging and Virtual Multimeter software. The data-logging program offers multi-channel, isolated 16-bit datalogging. The Virtual Multimeter program supports logging a user-defined choice of A/D signals, digital input states and card temperature into a disk file, at intervals that range from 55 ms to 60,000 minutes. Each data group can be prefixed with time or the log interval, which constitutes the X-axis if imported into a spreadsheet program. The software also offers programmable setting of input range and low-pass filtering. The K16/PC card contains eight 16-bit inputs that can be individually programmed for voltage or 4-to-20-mA current inputs. $399.

Saelig Co., 1193 Moseley Rd., Victor, NY 14564; tel.: 716-425-3753; fax: 716-425-3835.

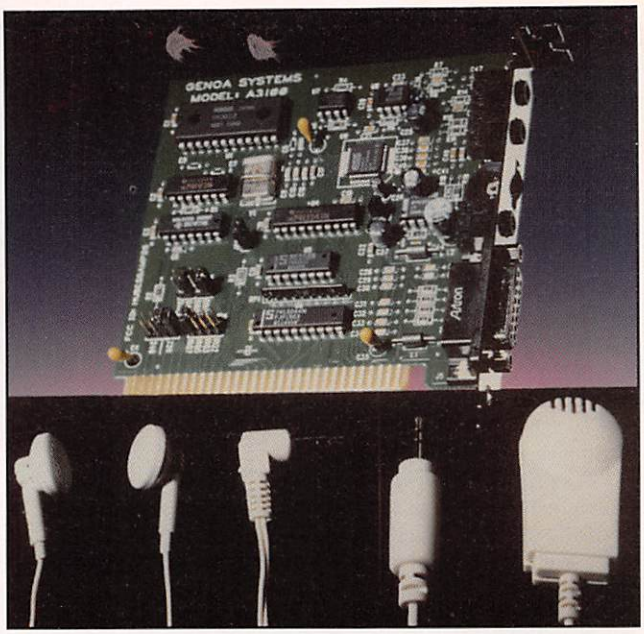
CIRCLE NO. 19 ON FREE CARD

SIMCHECK Interface

Aristo Computers' PC Communication Package links an IBM/compatible PC and the SIMCHECK memory tester. It consists of a small serial interface module that connects to SIMCHECK's expansion slot, an RS-232 serial cable and communication software for the PC. Test results can be saved on-disk, viewed and printed, and an unlimited number of test scripts can be set up and stored for future use. $295. *Aristo Computers, Inc., 6700 SW 105 Ave., Ste. 307, Beaverton, OR 97005; tel.: 503-626-6333; fax: 503-626- 6492.*

CIRCLE NO. 20 ON FREE CARD

SIMCHECK Interface



Affordable Sound Card

Affordable Sound Card

Genoa Systems' AudioBlitz Classic is a reasonably-priced, full-featured sound card that's claimed to be compatible with all industry standards. It features recording and playback in eight- or 16-bit mode, PCM or ADPCM compression modes, an FM synthesizer, direct line-level and microphone inputs for recording and an internal 4-watt audio amplifier. Also included is a two-player joystick port that can also be used as a MIDI interface. Earphones and software accessories round out the package. $79. *Genoa Systems, Corp., 75 E. Trimble Rd., San Jose, CA 95131; tel.: 408-432-9090; fax: 408-434-0997.*

CIRCLE NO. 21 ON FREE CARD

Computer Maintenance

Caig Laboratories' ProGold non-abrasive and non-corrosive formula conditions gold connectors to enhance conductivity characteristics for efficient transmit signals. Included with the ProGold Computer Kit #20 are: ProGold Spray, Wipes and Pen; CaiKleen, an ultra-pure alcohol for tape heads and other general cleaning; OpticALL for cleaning glass, metal and plastics; and lint-free accessories. ProGold Kit #10 additionally includes DustALL duster spray and StaticALL for neutralizing static build-up. *Caig Laboratories, Inc., 16744 W. Bernardo Dr., San Diego, CA 92127; tel.: 619-451-1799; fax: 619-451-2799.*

CIRCLE NO. 22 ON FREE CARD

Computer Maintenance

DoubleSpace: An Illustrated Tutorial

By Dan Gookin
(*Windcrest/McGraw-Hill. Soft cover. 133 pages. $15.95.*)
If you've moved up to MS-DOS 6.x for the purpose of doubling the storage capacity of your hard disk using DoubleSpace, you'll want to add this book to your PC library. It's written by an expert to guide you painlessly through installing and configuring DoubleSpace to avoid all the pitfalls that can crop up.

To put you in the proper frame of mind, the first chapter tells you all about disks and data storage. Once you have a foundation on which to build, Chapter 2 gets you into configuring DoubleSpace and includes important information on preparing for DoubleSpace, making a before-installation checklist and actual installation, with scenarios, the installation procedure and using the DOS editor. Chapter 3 gives you an overview of what installing DoubleSpace does to your system and talks about DoubleSpace and DOS memory management.

The remainder of the book deals with after-installation topics. These include adding more compressed drives, working with a compressed drive, altering a compressed drive, using DoubleSpace with *Windows* and using DoubleSpace utilities. The closing chapter is devoted to answers to frequently-asked questions.

To get the most out of this book—and, by inference, DoubleSpace—you don't have to be DOS expert or know anything about programming. In fact, even if you're a relative newcomer to computing, you should have little or no problem understanding and applying the information in this book. The text is well-written and easy to read, and it's supported by screen captures, drawings and useful programming examples that go a long way toward making DoubleSpace installation and tune-up for maximum utility a breeze.

66-MHz Color Notebook

Micro Express' new NB8266 active-matrix color notebook PC is based on the 486DX/2-66 microprocessor. Its 10" active-matrix TFT LCD color VGA display features CCFT back-lighting and a resolution of 640 x 480. The notebook PC also offers a Type III PCMCIA expansion slot, built-in trackball, intelligent power management, a 200M hard disk, 4M of RAM and flash BIOS. Also included are a 3½" floppy-disk drive, carrying case, quick-charge Ni-Cd battery and automatic-switching ac adapter. Weight is 7.2 pounds. $4,499. *Micro Express, 1801 Carnegie Ave., Santa Ana, CA 92705; tel.: 714-852-1400.*

CIRCLE NO. 23 ON FREE CARD

Printer Sharing

The ASP Computer Products SNAP Starter Kit printer-sharing system includes two transmitters and one receiver and two 25-foot cables. Lightweight, telephone-type modular cables link the transmitters to the receiver. The SNAP Receiver plugs into the standard Centronics parallel port of a printer, while the SNAP Transmitters plug into the parallel ports of two PCs. $159. *ASP Computer Products, Inc., 160 San Gabriel Dr., Sunnyvale, CA 94086; tel.: 408-746-2965; fax: 408-746-2803.*

CIRCLE NO. 24 ON FREE CARD

By Jan Axelson

How to Use a PC's Parallel Port for Monitoring and Control Purposes

Part 1

Signals, Cables and Interfacing

Just about all IBM-compatible personal computers have a parallel port that you can access via a rear-panel connector. The port's original purpose was to provide a printer interface, which is still its most common use. But users and product developers have also learned that the port's eight outputs, five inputs, and four bidirectional lines are enough for many basic monitoring, control, data-transfer and other applications. The result is that the parallel port has become a popular location into which to plug all kinds of things besides printers.

For circuit design and testing, there are parallel-port programmers, voltmeters, oscilloscopes and logic analyzers. For portable computers, or any computer that doesn't have an empty expansion slot or drive bay, you can buy parallel-port versions of standard add-ons like tape backup drives, network adapters, joystick interfaces, and even sound systems. Other products include car-engine diagnostic tools and controllers and data loggers of all types.

Because a parallel-port device plugs into the computer's rear panel, you don't have to open the cover of your system unit for installation, and you can easily move whatever device you connect to a different computer when needed.

In this two-part article I provide you with a guide to the PC's parallel port, including what you need to know to design your own parallel-port interfaces. You may also learn a few things that will help you better understand how to use the parallel port with printers and other commercial products.

Original Parallel Port

The standard parallel port offers just one of many ways to add user-accessible inputs and outputs to a personal computer. There are dozens of expansion cards with rear-panel connectors that permit access to various combinations of inputs and outputs. But the focus here is on the standard parallel port that just about every MS-DOS computer has.

The circuitry and connector for the parallel port are usually on an expansion card, although sometimes, especially in portable computers, the circuits are on the motherboard. Because the port circuits aren't complex, the expansion card almost always includes additional functions. Some parallel ports are on multifunction cards that include serial and game ports, while others are added to disk controllers or display adapters.

MS-DOS refers to the parallel port as LPT1 (line printer 1), or LPT2 and LPT3 for additional ports. Another name for the parallel port is printer port, reflecting its most common use. The rear-panel connector is a female 25-pin D-shell connector (not to be confused with the male 25-pin D-shell connectors used on many serial ports).

Each parallel port has one of three possible base addresses in memory: 3BCh, 378h, or 278h. You change address by moving a jumper or running a setup utility. Some ports permit just one or two of the three addresses, and a few let you to choose any uncommitted address, including nonstandard ones. If you lack documentation for a port, look on the card for labeled jumpers.

When the computer boots, a BIOS routine looks for a port at each of the three addresses in the order listed above. The BIOS determines whether or not a port exists by writing to it and then reading back what it wrote. If the read is successful, the port exists. The first port found is called LPT1, the second, LPT2, and the third, LPT3. So, LPT1 may be at any of the base addresses. If it exists, LPT2 may be at 378h or 278h, and LPT3 can only be at 278h.

The BIOS routine stores the port addresses in a table from 40:8 to 40:F, beginning with LPT1. The top two bytes (for LPT4) are rarely used.

You can swap printer designations by swapping the values in the table. Therefore, it's possible to vary from the original configuration. You might want to do this if a program supports only LPT1 and your printer is on port LPT2.

Two hardware interrupts, 5 and 7, are commonly associated with the parallel ports. Some cards allow you to select an interrupt with a jumper or setup utility, while others are hardwired to a specific interrupt.

Conventionally, LPT1 uses interrupt 7 and LPT2 uses interrupt 5. However, since on XT-type computers, the hard

Table 1. Signals and Their Functions on PC Parallel (Printer) Port

D-Shell Connector Pin	Signal	Function	I/O at D-Shell Connector	Register	Register Bit	Inverted at Register	Centronics Connector Pin
1	–STB	Strobe D0 Thru D7	I/O	Control	0	Y	1
2	D0	Data Bit 0	O*	Data	0	N	2
3	D1	Data Bit 1	O*	Data	1	N	3
4	D2	Data Bit 2	O*	Data	2	N	4
5	D3	Data Bit 3	O*	Data	3	N	5
6	D4	Data Bit 4	O*	Data	4	N	6
7	D5	Data Bit 5	O*	Data	5	N	7
8	D6	Data Bit 6	O*	Data	6	N	8
9	D7	Data Bit 7	O*	Data	7	N	9
10	–ACK	Acknowledge (Triggers interrupt)	I	Status	6	N	10
11	BSY	Printer Busy	I	Status	7	Y	11
12	PE	Paper End (Out of Paper)	I	Status	5	N	12
13	SEL	Printer Selected (On-Line)	I	Status	4	N	13
14	–AUTOLF	Automatic Line Feed After CR	I/O	Control	1	Y	14
15	–ERR	Error	I	Status	3	N	32
16	–INIT	Initialize Printer	I/O	Control	2	N	31
17	–SELIN	Select Printer (Plate On-Line)	I/O	Control	3	Y	36
18-25	GND	Ground	I	—	—	N	16, 19-30,33
—	NC	No Connection at PC	—	—	—	—	15,17,18,34,35

*Some data ports are bidirectional (I/O).

disk uses interrupt 5, it's not available for the parallel port.

Although interrupt-driven software is fast, most parallel-port printer drivers don't use interrupts. This is partly due to a problem on the original parallel port and many of its imitators. On these ports, the interrupt-request line isn't latched. So if the pulse is short, the computer may not see it at all.

Table 1 summarizes the signals at the parallel port connector. These signals more or less follow the printer interface popularized by the Centronics Data Computer Corporation, although the 25-pin connector doesn't use all of the 36 lines in the original interface. Centronics was an early manufacturer of low-cost dot-matrix printers, and, although Centronics printers are no longer made, the name lives on in the connector, signals and pinout that the company made popular.

Although each signal has a name that suggests a particular function, you don't have to use the signals for their intended purposes. For example, you can use the paper-end signal for any type of input, not just to announce that a printer is out of paper.

• ***Inputs and Outputs.*** You can access the parallel port through both MS-DOS and the ROM BIOS. Services 00, 01, and 02 of BIOS interrupt 17h enable you to send a byte to the printer, initialize the printer and get printer status. DOS interrupt 21h, function 05, also writes a byte to the printer, and function 40h can direct a block of data to a parallel port. But for full access to all of the port's 17 signals, you need to read and write directly to the port. To do this, you ignore the DOS and BIOS functions and instead read from and write directly to the port's data, status and control registers shown in Fig. 1.

• ***Data Lines.*** Data lines D0 through D7 are eight outputs that carry the data to be printed to the printer. For other applications, you can use the data lines as general-purpose outputs. To control the states of pins 2 through 9 on the parallel connector, you just write the desired data to the data register, whose address is the base address of the port. For example, to bring high D4 through D7 and low D0 through D3, you'd write F0h to the data register. In BASIC, you use the OUT statement, as follows:

```
OUT DataRegisterAddress, DataPortData
```

or, using the base address 3BCh and data F0h,

```
OUT &h3BC,&hF0
```

Listing 1 is a QuickBASIC program that brings each of a data-port pins high, one at a time.

Some parallel ports have bidirectional data lines, which you can use as inputs as well as outputs. Later, I'll explain how to determine if you have a bidirectional port and how to use a bidirectional data port for input.

• ***Status Lines.*** The status lines are five inputs that you read at a status register, which has an address of base address +1, or 3BDh for a port with a base address of 3BCh. The status register is read-only; writing to it has no effect. The five status lines use Bits 3 through 7 in the register, corresponding to pins 10 through 13 and 15 at the connector. Bits 0, 1 and 2 aren't used. To read the status inputs, you read the status port. In BASIC, you use the INP function:

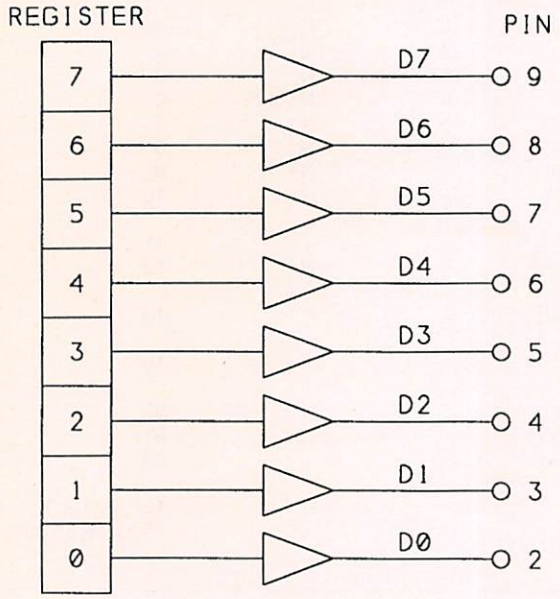
```
PRINT INP(StatusPortAddress)
```

or instead use

```
PRINT INP(&h3BD)
```

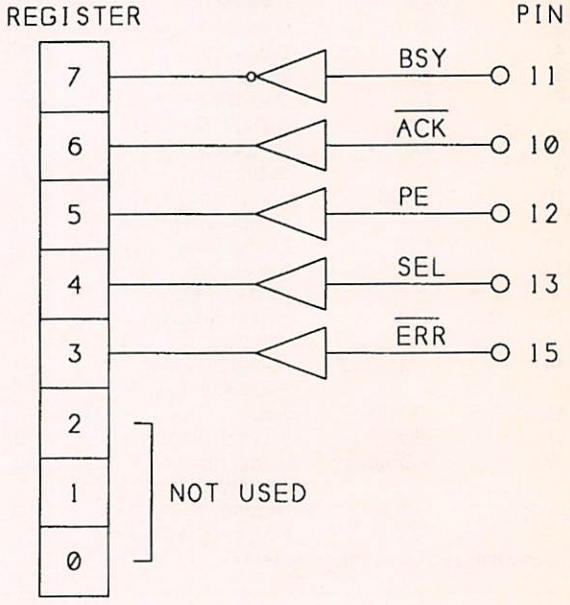
However, the value you read doesn't exactly match the logic states at the connector. Bits 3 through 6 read normally. The bits in the status register match the logic states of their corresponding pins. Bit 7, however, contains the complement of the logic

DATA REGISTER
8 OUTPUTS



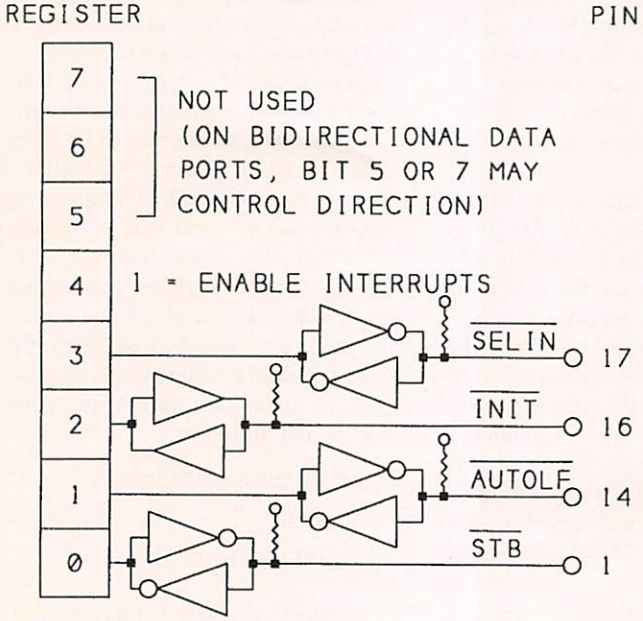
SOME DATA PORTS ARE BIDIRECTIONAL.

STATUS REGISTER
5 INPUTS



WITH INTERRUPTS ENABLED, TRANSITIONS AT PIN 10 (ACK) TRIGGER INTERRUPTS.

CONTROL REGISTER
4 BIDIRECTIONAL LINES



TO USE BITS 0-3 AS INPUTS, WRITE 04 TO THE CONTROL REGISTER.

POSSIBLE REGISTER ADDRESSES

DATA (BASE ADDRESS)	STATUS (BASE+1)	CONTROL (BASE+2)
3BCH	3BDH	3BEH
378H	379H	37AH
278H	279H	27AH

Fig. 1. The computer uses these three registers to read from and write to the parallel port.

state at pin 11 (BUSY). So, to find the actual logic states at the connector, you complement, or invert, Bit 7.

The Boolean Exclusive-OR (XOR) operator is an easy way to invert one or more bits in a byte, while leaving the other bits unchanged. As the following truth table shows, the result of an XOR operation is 1 only when the inputs consist of one 1 and one 0:

A	B	A XOR B
0	0	0
0	1	1
1	0	1
1	1	0

To invert selected bits in a byte, first create a mask byte in which the bits you want to invert are 1s and the bits to ignore are 0s. For example, to invert Bit 7, the mask byte would be 10000000, or 80h. If you XOR this byte with the byte read from the status register, you end up with the actual value at the connector. The mask byte gets its name because the 0s mask, or hide, the bits you don't want to change. Here's an example:

10101XXX	Status port inputs, Bits 3 through 7, at connector (X = don't care)
00101XXX	Result when you read the status register (Bit 7 inverted)
10000000	Mask byte to make Bit 7 match connector
10101XXX	XOR of previous two bytes; result matches logic states at connector

This BASIC statement will display the actual logic states at the status-port pins, for a port with a base address of 3BCh:

```
PRINT INP(&h3BD XOR &h80)
```

Listing 2 is a BASIC program that reads the status port and displays the logic state at each of the status inputs.

• ***Control Lines.*** In addition to the data and status ports, the parallel port contains a bidirectional control port. You can use its four lines as inputs or outputs, in any combination. The control register's address is base address + 2, or 3BEh for a port with a base address of 3BCh. The four control lines use Bits 0 through 3 in the register, which correspond to pins 1, 14, 16 and 17 on the connector.

Bit four enables the parallel port's hardware interrupt. When Bit 4 is high, a falling edge at status input ACK (pin 10) generates an interrupt. (A few ports interrupt on the rising edge of ACK.) To use the interrupt, you must install an interrupt routine that responds to the port's assigned interrupt. If you aren't using the interrupt, don't bring high Bit 4. Bits 5, 6 and 7 in the control port are unused in most parallel ports. In ports with bidirectional data lines, Bit 5 or 7 may configure the port as input or output.

To write to the control lines, you write to the control register:

```
OUT ControlRegisterAddress,
ControlPortData
```

This statement writes 0Ah to a control register at 3BEh:

```
OUT &h3BE, &h0A
```

Like the status port, the control port

Listing 1. Routine For Writing to Parallel Port's Data Lines

```
' Bit #    Pin on 25-pin D-connector
' 0        2
' 1        3
' 2        4
' 3        5
' 4        6
' 5        7
' 6        8
' 7        9

'The program brings each of the data lines high, one at a time.
'After each write, the program pauses until you press a key.

DataPort = &H3BC:                    'set to match address of current port
                                     '(3BCh, 378h, 278h)

 FOR I = 0 TO 7                      'bring each of the 8 data bits high in turn
  OUT DataPort, 2 ^ I
  PRINT "Data Port Bit "; I; " is high"
  PRINT "Press any key to continue..."
  DO: LOOP WHILE INKEY$ = ""         'wait for key press
 NEXT I

END
```

Listing 2. Routine For Reading Parallel Port's Status Lines

```
' Bit #    Pin on 25-pin D-connector
' 3        15
' 4        13
' 5        12
' 6        10
' 7        11

'The program reads the status register and displays the result.

StatusPort = &H3BD                   'set to match address of current port
                                     '(3BDh, 379h, 279h)

 A = INP(StatusPort):                'read status register
 A = A XOR &H80:                     'register contains complement of bit 7
                                     'XORing with 10000000 gives the value
                                     'at the connector
A = A AND &HF8:                      'ignore bits 0-2

 PRINT "Status Port = "; HEX$(A)
                                     'display hex value of bits 3-7 at connector
 FOR I = 3 TO 7                      'display each bit individually

  PRINT "Status Port Bit "; I; " = "; (A AND 2 ^ I) / 2 ^ I
NEXT I

END
```

Listing 3. Routine For Writing to Parallel Port's Control Lines

```
' Bit #    Pin on 25-pin D-connector
' 0        1
' 1        14
' 2        16
' 3        17

'The program brings each of the control port's 4 bits high, one at a time.
'After each write, the program pauses until you press a key.
'
ControlPort = &H3BE:                'set to match address of current port
                                    '(3BEh, 37Ah, 27Ah)

 FOR I = 0 TO 3                     'bring each of the 4 control bits high in turn
   A = (2 ^ I XOR &HB               'At the connnector, bits 0,1, and 3 are the
                                    'complements of the values in the control
                                    'register. XORing with 00001011 gives the
                                    'intended outputs at the connector.
   OUT ControlPort, A
   PRINT "Control Port Bit "; I; "is high"
   PRINT "Press any key to continue..."
   DO: LOOP WHILE INKEY$ = ""  'wait for user to press a key
 NEXT I

END
```

has inverted bits. At the connector, Bits 0, 1 and 3 are the complements of their logic states in the control register. Only Bit 2 reads normally. So, if you write 0Fh to the control register, you actually write 04h to the connector. To make the value you write match the result at the connector, XOR the value with 0Bh (00001011), as this example shows:

```
OUT &h3BE, &h0A XOR &h0B
```

Listing 3 is a BASIC program that brings high each of the control port's bits in turn.

You can also use the control lines as inputs. In early designs, the control port's outputs were 7405 open-collector inverters with 4,700-ohm pull-up resistors. The outputs also connect to input buffers. When the open-collector outputs are high, you can drive the input buffers with other digital out puts. In newer port designs, the components vary, but the port should retain the ability to use a control bit as input when the output is high. Figure 2 shows the difference between open-collector outputs and the other common type of output, the totem-pole.

At an open-collector output, a low output causes the output transistor to conduct, creating a low resistance from the output pin to ground. A high output requires a pull-up resistor to bring the output to a valid logic-high level. If you connect a high output to ground, current flows through the pull-up resistor, but with a 4,700-ohm resistor, it's just a little over 1 mA. This is why you can tie together two or more open-collector outputs, and any low will bring low the combined output. This is often called a "wired-OR" gate, although in positive logic (high = 1 and low = 0), the outputs form an AND gate, with any low output bringing low the combined output.

The outputs of some NMOS and CMOS devices are similar to open-collector in this way. They have on-chip pull-up devices, and writing a 1 to an output allows you to use it as input. The ports on the 8051 and 80C51 microcontrollers are examples of this type of output. In contrast to open-collector, most LSTTL devices have a different type of output, called totem-pole, with two transistors stacked one above the other "totem-pole" style. When the output is low, the lower output transistor conducts, similar to an open-collector output. But when the output is high, the upper transistor conducts, creating a low-resistance path to +5 volts.

If you tie together two totem-pole outputs, when one is high and the other is low, you end up with a lot of current in the output transistors as they battle for control. The resulting logic level is unpredictable. More importantly, the currents may destroy the components. Outputs on most digital CMOS devices have complementary outputs that are similar to totem-pole.

If you tie a totem-pole output to an open-collector output, you're okay if the open-collector output stays high. If it goes low and the totem-pole output is high, you end up with the same battle for control and excess currents. So, to prevent problems, use open-collector outputs to drive the control inputs.

To bring high all four of the control port's outputs to use the bits for input, write 04 to the control register:

```
OUT &h3BE, 4
```

Because bits 0, 1 and 3 are inverted at the connector, you write 04, not 0F, to bring Bits 0 through 3 high. To read the control inputs, you then read the control register with:

```
PRINT INP(ControlRegisterAddress)
```

or else

```
PRINT INP(&h3BE)
```

The value read has Bits 0, 1 and 3 inverted from their logic states at the connector. To re-invert Bits 0, 1 and 3 and display the actual value at the connector, use this statement:

```
PRINT INP(&h3BE) XOR &h0B
```

Listing 4 is a BASIC program that reads the control port and displays the logic state at each of the control inputs.

• ***Bidirectional Data Ports.*** If you need eight bits of input, you can combine inputs from the status and control ports to achieve a byte of input data. For some applications, though, it would be convenient to use the data port as an eight-bit input, and sometimes you can do just this.

In older PCs, and many newer ones, the data port is designed for only output. In the original design, the data outputs were driven by a 74LS374 octal flip-flop. The data pins also connect to an input buffer, but reading the buffer tells you only the last value written to the outputs. (The input buffer is what enables you to test for the existence of the port by writing to it and then reading back what you wrote.) But because there's no way to turn off the outputs, you can't read

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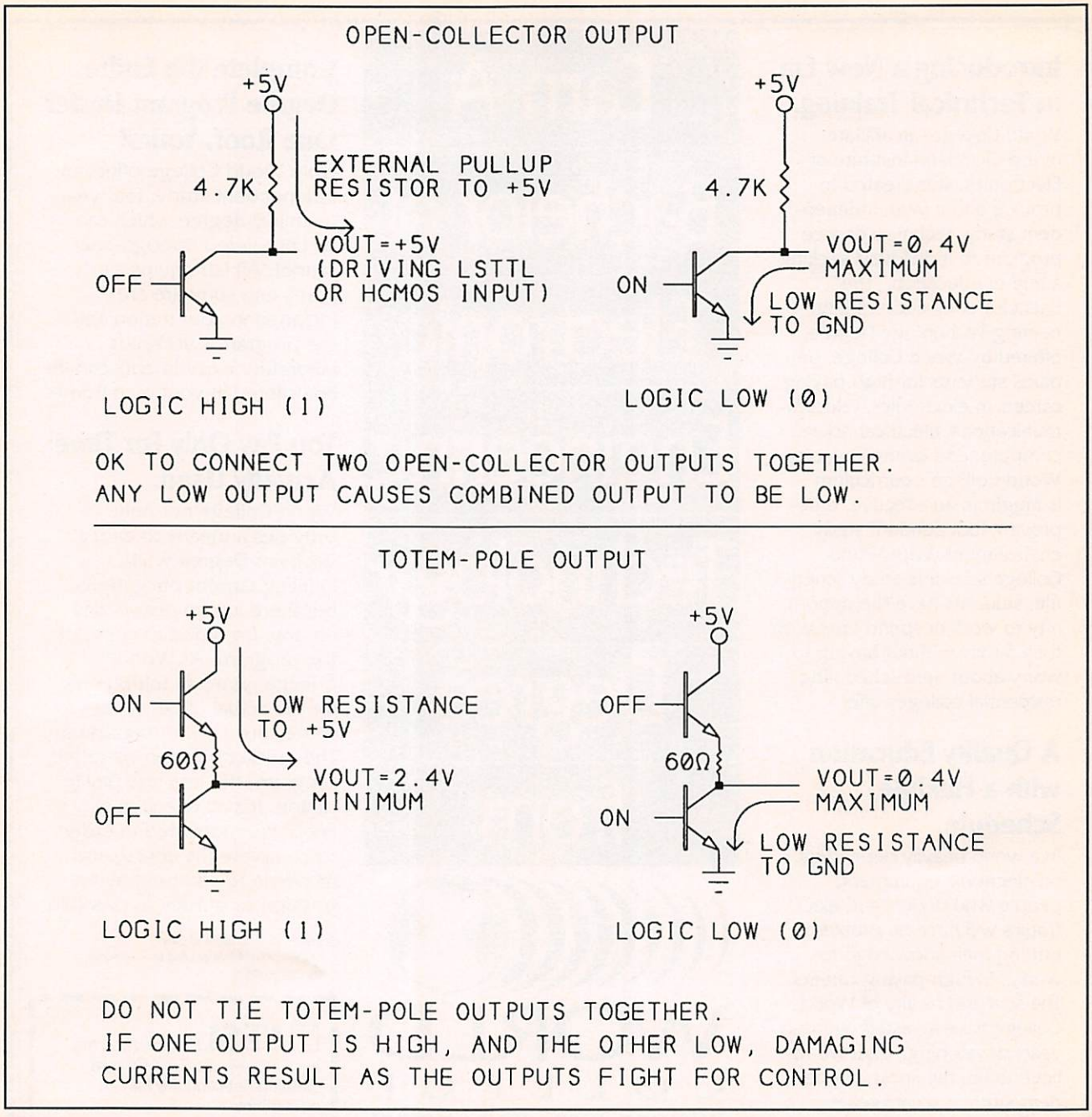

Fig. 2. At parallel ports that have open-collector or similar outputs, you can drive the input buffer with an external source. At ports that have totem-pole outputs, driving the input buffer with an external source has unpredictable results and may damage the circuits.

external signals at the data port. In fact, connecting outputs to the data port may destroy the port's circuits.

Beginning with its PS/2 model in 1987, IBM began to offer a bidirectional parallel port, the data lines of which can function as inputs as well as outputs. Other computer vendors have also added bidirectional ports. For example, computers that use Intel's 386SL or 486SL Superset have an I/O Subsystem chip that includes a bidirectional parallel port.

Typically, to use a bidirectional port for input, you must first run a setup program or move a jumper to configure the port for bidirectional operation. You then select input or output by setting or clearing a bit in the control register—usually Bit 5, but some ports use Bit 7.

If your computer doesn't have a bidirectional port, you can get one by adding an inexpensive expansion card. Essential Data carries several, including STB's DSP550 ($37), with one parallel port and two high-speed serial ports. Other suppliers have similar products. But many cards and computers, even newer ones, still don't have bidirectional data lines. Also, because all parallel ports have status and control inputs, any vendor can call its ports bidirectional, even if the eight-bit data port is output-only. So be sure you know what you're

Listing 4. Routine For Reading Parallel Port's Control Lines

```
' Bit #    Pin on 25-pin D-connector
' 0        1
' 1        14
' 2        16
' 3        17

'The program reads the control register and displays the result.

ControlPort = &H3BE:                'set to match address of current port
                                    '(3BEh, 37Ah, 27Ah)

OUT ControlPort, 4 AND &HF:         'bring bits 0-3 high to allow use as inputs

A = INP(ControlPort):               'read control register
A = A XOR &HB:                      'register contains complements of bits 0,1,3
                                    'exclusive ORing with 00001011 gives
                                    'the values at the connector
 A = A AND &HF:                     'ignore bits 4-7
 PRINT "Control Port = "; HEX$(A)

                                    'display hex value of bits 0-3 at connector
 FOR I = 0 TO 3                     'display each bit individually
   PRINT "Bit ", I, " = ", (A AND 2 ^ I) / 2 ^ I
NEXT I

END
```

buying, or that you can return the card if it doesn't do what you need.

For the adventurous, it's possible to use some output-only data ports for input. On some ports you can bring high the data outputs and drive the input buffer with an external signal, much as you do on the control port. This method risks component damage if you make a mistake, and maximum speed may be less than that of a true bidirectional port. This said, to understand how to use an output port for input, you need to examine the circuits involved.

Although it's convenient to think of digital logic as a collection of logic gates that respond perfectly to their inputs, sometimes it's necessary to see what is actually driving the circuits. On the original parallel port, a 74LS374 provided the data outputs. These days, there's no telling exactly what's connected to the port pins. In researching this article, I examined several parallel ports of different vintages. One older card did, indeed, use a 74LS374 to drive the data port and other common DIP ICs for the status and control lines. On another card, a single 100-lead surface-mount chip contained almost all of the circuits needed to control the parallel port and a monochrome display adapter. My guess is that the chip is an ASIC (application-specific IC) designed for the expansion card. On a third card, which also contained a disk controller, the parallel port and other circuits were controlled by a 68-lead LCC (leaded chip carrier) with the designation HM83C452. A crystal connected to two of the leads, which makes me suspect that the chip is a microcontroller of some type. Since Philips' 83C451 is a version of the 80C51 microcontroller in a 68-lead LCC, perhaps the 83C452 is a similar chip.

At any rate, the actual components that control the parallel port vary widely. To use an "output-only" data port for input, you must have outputs that use open-collector or a similar design. You can't use totem-pole outputs like the 74LS374s.

If you have a schematic diagram of your port, you can use it to find out what's driving your data outputs. If they use a 74LS374, you can't use the data port for input, unless you modify the circuits as described below. For other components, if the part number is recognizable, you can consult a data book for details about the chip. Alternatively, you can perform the following tests:

First, write FFh to the data port and measure the voltages at pins 2 through 9. If you measure less than 4.5 volts, the outputs are probably totem-pole,

and the port isn't suitable for input. If you measure close to +5 volts, connect a 1,000-ohm pull-down resistor from output to ground. If the output voltage drops by 0.5 volt or more, the output is probably open-collector or similar. This means that you can use the data port for input by writing FF to the data port and then driving the input buffer with a 7406 or another strong open-collector driver. Reading the data port should then tell you the logic states at the external driver's outputs. See the December 1992 *ComputerCraft* for more details on this method, including how to connect two computers for bidirectional transfer. (Back issues of *ComputerCraft* are available for $3.50 each from *MicroComputer Journal*.)

If you have a card that uses a 74LS374 for the data outputs, you can make the port bidirectional by modifying the circuits. Although buying a card with a true bidirectional port is easier, quicker and economical, the following are two options for the determined:

(1) Make and add a small daughterboard that replaces the 74LS374 with 7407s or another open-collector device with pull-up resistors. The July 1993 issue of *ComputerCraft* has details on this.

(2) Control the 74LS374's outputs by cutting the ground connection at the 74LS374's OE (output-enable line) at pin 1 and tying pin 1 to one of the parallel port's control outputs. This control bit then determines the port's direction, where 0 enables the data outputs for an output port and 1 disables the outputs and allows you to use the data port for input.

Speed

How fast can you read or write to the parallel port? The answer depends on the speed of your computer and the speed of your software, which depends on both the programming language and the program you write. Using assembly language, you can read the parallel port and store the value in memory or write a value from memory to the port, using just a few instructions. However, most real-world applications involve more than these basic operations, and any processing or calculations on the data will slow the transfer rate. Using BASIC, C or any compiled or interpreted programming language will also slow things.

As a very general rule, it's possible to achieve transfer rates of 40K to 80K bytes per second on fast computers, and 10K to 15K bytes per second on an 8-MHz machine.

Some newer port designs, including the enhanced parallel port in Intel's SL chipset, and ports that follow the IEEE's new 1284 standard, can transfer data at 1M byte per second. Some network adapters, drives and other parallel-port devices use these faster methods when they detect a high-speed port.

Parallel-Port Cables

For experimenting with a parallel port, you need a cable that permits easy access to the signal lines. Standard printer cables typically have a male 25-contact D-shell connector on the computer end and a male 36-contact Centronics connector on the printer end (with 11 contacts that aren't used). Therefore, one solution is to use a standard printer cable and wire a 36-contact female Centronics connector to your circuits. If you want to use a different type of cable or connector, for best results, there are some things to be aware of.

In an ideal cable, the signal at an input exactly matches the output that drives it. In reality, as signals travel along a cable, they degrade and pick up noise due to the conductor's resistance, crosstalk from adjacent conductors, reflected signals, poor grounding and other problems. Unlike the RS-232 serial interface, which can use cables of 100 feet and longer without problems, parallel-port circuits aren't designed for data transfers over long distances. This is why parallel cables are typically 15 feet or less in length. There are some things you can do to minimize problems in parallel links, however.

Metal shielding blocks radio-frequency (rf) interference and also prevents capacitive coupling between conductors on opposite sides of the shield. Most standard printer cables are shielded with a foil or other metal covering around the conductor bundle for the length of the cable. On some molded cables, shielding extends to the connectors. Shielding does nothing to prevent magnetic, or inductive, coupling between conductors in the cable, how-

ever, and this can be a bigger problem. A simple way to minimize magnetic coupling is to use twisted-pair cable in which each conductor is paired with another and the conductors in each pair wind around each other with a full twist every inch or two.

Ideally, in a twisted-pair cable, each signal conductor is paired with a ground conductor that provides a return path. This minimizes the area of the current loop formed by the signal and return conductors, which, in turn, reduces the ability of signals to magnetically couple into adjacent conductors. Also, twisting causes noise that's picked up in one twist to tend to cancel in the next.

Unfortunately, the parallel-port connector doesn't have sufficient pins to give each of the 17 signals its own ground return. You do get eight ground pins, though. So, as a last resort, you could tie two conductors to a pin.

Ordinary ribbon cable doesn't have twisted pairs, but the ground conductors in the cable alternate with D3 through D7 and the four status lines. This helps to reduce noise. You can also buy twisted-pair ribbon cable, which has 18" sections of twisted pairs alternating with 2" flat untwisted sections to permit crimping IDCs (insulation-displacement connectors). Digi-Key is one source for these.

If you use a cable with D-shell connectors on both ends, be sure that the cable contains 25 conductors. Many serial cables use 25-pin D-shell connectors, but the cables themselves have 10 or fewer conductors.

Connectors

If you want to use a solderless breadboard or perforated board that has holes on 0.1" centers, the pin spacing on a Centronics or D-shell connector doesn't match. A few perforated boards have pads intended for a D-shell connector. If you have one of these, you can use a pc-board-mount connector, or you can use a solder-cup D-shell connector and solder individual conductors to it.

For use with a solderless breadboard, another option is to use a 25-conductor ribbon cable with a male D-shell connector on one end and a DIP connector on the other. The DIP connector has two rows of pins with the same spacing as a DIP IC. The ribbon cable slides under the connector's cover and crimps onto the tops of the pins. The connector then plugs into a breadboard, perforated board or IC socket, permitting easy access to all of the port's lines.

Hand-held IDC tools are available for crimping onto ribbon cable, or you can just use a vise to press the cable onto the contacts.

Another option for use with perforated board is a ribbon cable that has a dual-row socket connector that plugs into a dual header. Digi-Key is one of many sources for connectors.

Port Interfacing

The parallel port uses ordinary 5-volt logic, or at best bus drivers and receivers, to send and receive over cables of 8 to 15 feet in length. The correct interface to these components can reduce problems due to noise or signal degradation. For best results, follow these guidelines:

Use plenty of decoupling capacitors. Connect a capacitor from +5 volts to ground at each IC that connects to the cable. Use a type of capacitor that has good high-frequency response, such as ceramic, mica or polystyrene. Keep the conductors or traces between the capacitors' leads and the ICs +5 volts and ground pins as short as possible. A good, general-purpose value is 0.1-µF, but exact value isn't critical. Also place a 10-µF electrolytic capacitor on the board, from +5 volts to ground, near where the 5-volt supply enters the board.

The decoupling capacitors store energy needed by the logic gates as they switch. All logic gates draw current as they respond to changes at their inputs. When the current is available from a nearby capacitor, the gate can switch quickly, without causing spikes in the power-supply or ground lines.

The capacitor should be located physically near the chip it supplies to minimize the inductance of the loop formed by the connections between capacitor and chip. Low inductance means faster response.

The drivers and receivers you connect to a parallel-port cable also affect signal quality. For greatest noise immunity at inputs driven by the parallel-port's data or control outputs, use devices with Schmitt-trigger inputs,

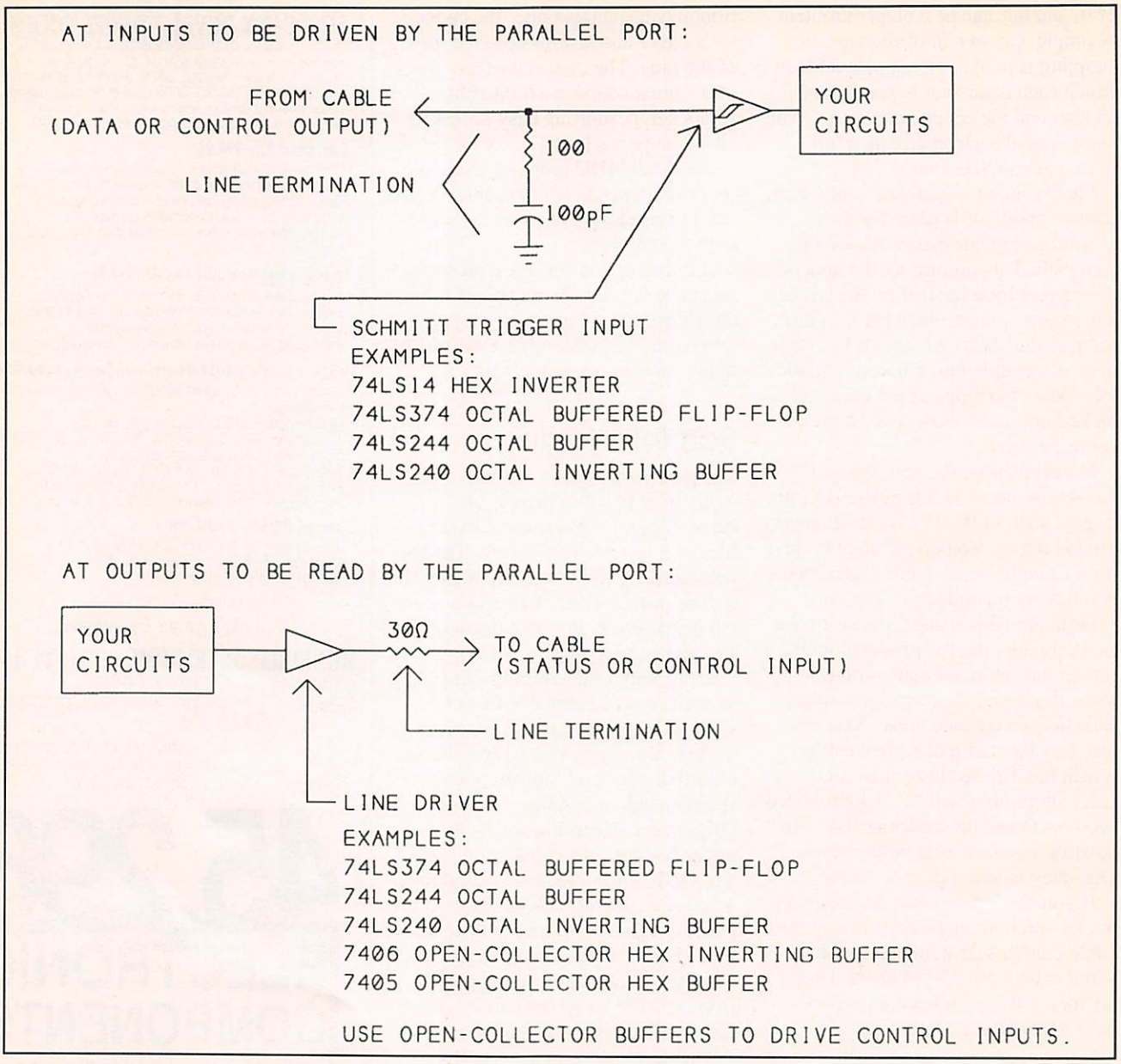

Fig. 3. Parallel-port interfaces.

such as the 74LS14 hex inverter. Figure 3 lists other options. At an ordinary logic gate, if a slowly changing input approaches the switching threshold, the output will jitter as the gate tries to decide whether the input is high or low. Schmitt triggers solve the problem by having two switching thresholds, one for low-to-high transitions and another, lower threshold for high-to-low transitions. For example, the output of a 74LS14 inverter won't go low until the input reaches 1.6 volts. After the output switches low, it won't go high again until the input drops to 0.8 volt. The 0.8-volt difference between the two thresholds is called hysteresis and prevents the output from jittering if the input is changing slowly or if it has some noise or ringing on it.

At outputs that drive parallel-port status, control or data inputs, use buffers or line drivers with strong output-drive ability. For example, on the 74LS240, low outputs can typically sink 24 mA per output, and high outputs can source 12 mA, compared with 8 and 0.4 mA for ordinary LSTTL. Figure 3 lists other line drivers. In general, CMOS drivers, including HCMOS, aren't as strong as LSTTL.

Remember to use open-collector devices to drive the control inputs and "output-only" data ports that you've determined can be used for input. Don't connect clock or control signals that aren't buffered—including the inputs and outputs of flip-flops, counters and shift registers—directly to the cable. These devices are sensitive to signal reflections. Instead, use buffers to isolate the signals. Some chips, like the 74LS374, have buffered outputs.

If you aren't using the status inputs, tie them to +5 volts or ground through a 4,700-ohm resistor to hold them at a valid logic level.

Another important issue for good signal quality is proper electrical ter-

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mination of the conductors in the cable. To understand termination, you again have to think of the cable as more than a simple series of connections between logic inputs and outputs. When a long conductor carries high-frequency signals, it has characteristics of a transmission line, which is a circuit that transfers energy from a source to a load. Because the sharp edges of digital transitions contain high-frequency components, digital circuits are considered high-frequency, even if the transmission rate (bits-per-second) is slow.

For the most efficient energy transfer from the source (output) to the load (input), the input impedance should match the characteristic impedance of the wire. Measuring the characteristic impedance of a conductor involves more than a simple measurement with an ohmmeter. The value varies with the conductor's diameter, insulation type and distance between it and other conductors in the cable. It doesn't, however, change with the length of the conductor.

Cable manufacturers often specify the characteristic impedance of their products. A typical value for twisted-pair and ribbon cable is 100 ohms.

When load and conductor impedances match, all of the energy is transferred to the load. If they don't match, some of the energy reflects back to the source, and the reflections may bounce back and forth several times before they die out. This can cause delays or invalid logic levels at the receiver.

Designing terminations for the parallel port is especially difficult because the exact port circuits vary with the computer. Using the wrong termination can slow the data or consume excess power. Figure 3 shows typical examples of terminations at inputs and outputs.

At the driver, a series resistor provides impedance matching. The resistor's value should equal the line's characteristic impedance, minus the resistance of the output. Some parallel-port cards include a 30-ohm resistor in series with each data output. You can do the same for outputs that drive the status or control inputs.

At the receiver, a resistor/capacitor combination network terminates the line. The resistor's value equals the characteristic impedance of the con ductor, and the capacitor provides a low impedance during switching. Unlike some other terminations, this one is usable in both LSTTL and CMOS circuits.

Transmission-line theory, including line terminations, is a field of study unto itself. If you want to know more, *National Semiconductor's Interface: Line Drivers and Receivers* data book (#40032) has several application notes on the topic.

Transmitting Over Long Distances

If the parallel port's 15-foot limit isn't long enough for what you want to do,

there are solutions. Parallel-port extenders are available from many sources, including Misco, Personal Computing Tools and Radio Shack, to name a few.

One type of extender adds a line booster, or repeater, that regenerates the signals in the middle of the cable, allowing you to double the cable length. For longer distances, there are parallel-port extenders that are advertised to work over distances as long as 1,400 feet. This type converts the parallel signals into serial format, usually RS-232, RS-422 or RS-485. The serial links use large voltage swings, controlled slew rates and other techniques for reliable transmission over longer distances. You could do the same for each of the lines in a parallel link, but as distance increases, it makes sense to convert to serial and save money on cabling.

One drawback to the parallel-to-serial converters is that most are one-way-only and include only the eight data lines. A few permit transmitting in both directions, but again using only the data port, which must, of course, be bidirectional. Also, the serial links can be slow. After adding a stop, start and parity bit for each byte, a 9,600-bps link transmits less than 900 data bytes per second.

If you need to use long cables, instead of employing a serial converter, you might consider designing your circuit to use a serial interface directly. There are reasons to prefer the parallel port, however, such as availability of a free port.

Resources

A very good reference on parallel and serial ports is *Build Your Own Low-cost Data Acquisition and Display Devices* by Jeffery Hirst Johnson (TAB Books, $19.95). It covers much more than the title suggests and includes serial- and parallel-port programming tools and plenty of detail on how to use the ports for unconventional purposes.

Parallel Technologies offers consulting and product development for the parallel port and distributes a free utility that finds and analyzes the parallel ports in your computer. The program lists your computer's port's addresses, bidirectional ability, assigned interrupts and more. There's also a speed test that estimates the maximum data-transfer speed for a port. You can find the utility, called PARA13.ZIP, in the IBM Hardware forum on CompuServe and on other BBSes. At this writing, the current version is V1.34.

Next time, I'll give more details on parallel ports. I'll include application examples and interrupts.

You can reach me on CompuServe at 71163,3555, on Internet at 71163.3555@compuserve.com or by mail at Box 3374, Madison, WI 53704-0374. For a personal reply by mail, please include a self-addressed stamped envelope. ■

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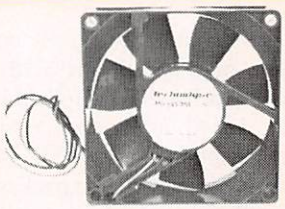

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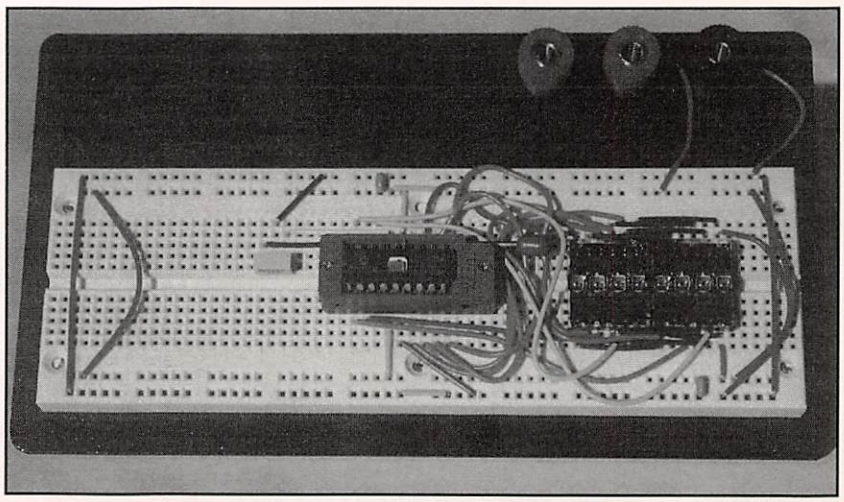
By Fred Eady

Getting to Know the PIC16C54 Microcontroller

A tutorial on what this handy device is and how you can use it in your own designs, with example programming code to show you what to do



By now, you've probably heard and read about the PIC microcontroller and wondered how you can make use of it but lack the information needed to get you started. Like many other microcontroller devices that are relatively new to the technological marketplace, the PIC microcontroller family comes with a couple of 2"-thick technical manuals. However, it lacks a decent implementation manual to make it a practical item in your design arsenal. In response to all of you have expressed tthe need for a get-me-started PIC tutorial, I offer this article to get you started experimenting with and implementing PICs in your own designs.

In this tutorial, I'll introduce you to a new and very popular RISC-like (RISC is an acronym for Reduced Instruction Set Computer) microcontroller called PIC from Microchip Technology. Specifically, I'll be discussing the PIC16C5X microcontrollers that clock from dc to 20 MHz, use low-power CMOS technology, feature eight to 20 I/O lines and incorporate sleep, timer and watchdog functions. It's my intent to give you some simple, yet powerful, application ideas you can assemble on a solderless breadboard socket or apply to a more-permanent printed circuit design as I intermix some PIC theory along the way.

If you who don't own a PIC16C5X programmer, a necessity for working with this device, I offer an inexpensive kit ($69.95) which you can use to program the PIC16C54 used in this tutorial. With this kit, you can program, read, blank check and verify the entire PIC16C5X series of microcontrollers.

Additionally, I offer the components needed to assemble the test circuit ($39.95, not including breadboarding socket) you'll be using to perform the experiments outlined here. Call your order in on 407-545-9905, or write ED Technical Publications, PO Box 54122, Merritt Island, FL 32954.

General Information

PIC16C5X microcontrollers are eight-bit RISC-like devices that are low in cost, consume little power, and operate at high speed. These 18- and 28-pin CMOS devices offer EPROM, RAM, I/O and a CPU on a single chip (see Fig. 1 for pinout details). Also available are PIC OTP (one-time-programmable) devices that aren't erasable, are housed inside plastic packages, are less expensive and are usually found in designs in which no future code changes are expected to occur. OTP devices are great for testing since the PIC16C54/RC OTP can be had from Digi-Key for $4 in 10-piece quantity (tel: 1-800-DIGI KEY).

EPROM-based PICs normally feature ceramic packages that have a transparent window that permits erasure and reuse of the devices. Though EPROM-equipped PICs are great for testing and prototyping because of their reusability, be aware that you'll pay a much more for this convenience. Our examples will exploit the PIC16C54 with EPROM because it can be erased and reused during experimentation.

To get the most from this article, you need a solderless breadboarding socket, an EPROM-based PIC16C54, two DL-1414 intelligent displays, an 8-MHz ceramic oscillator and a 5-volt dc power supply. You'll be writing and assembling small segments of PIC code and observing the results of your work with a logic probe, LEDs or on a pair of four-digit displays. You also need a PIC16C5X pro-

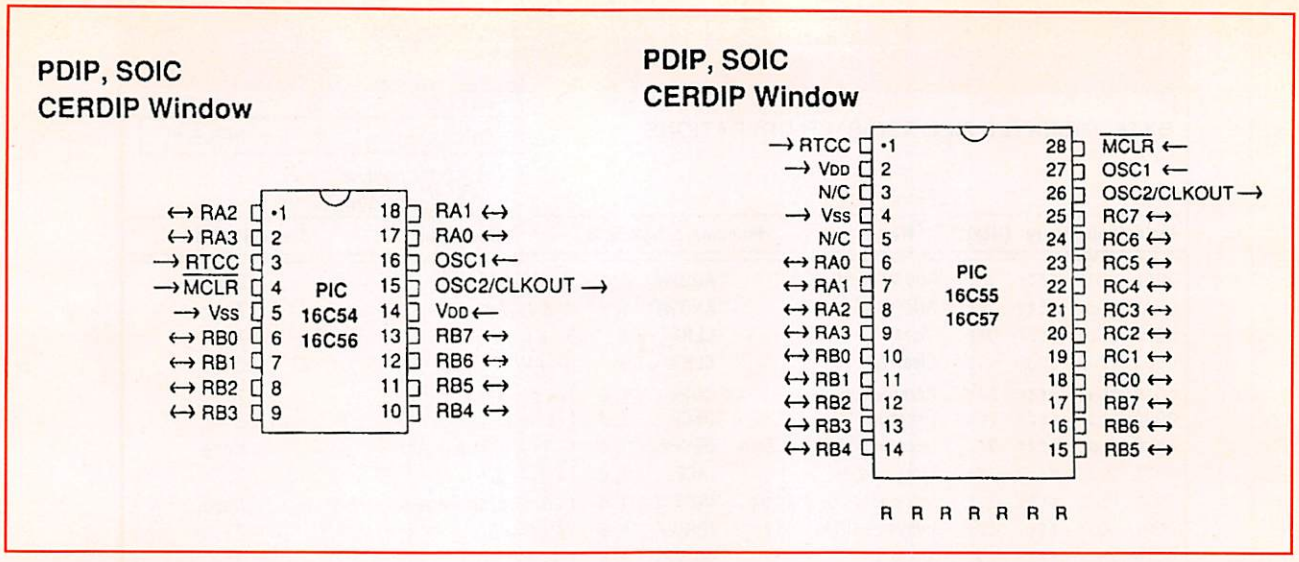


Fig. 1. Pinout diagram of PIC16C5X microcontroller in (left) 18- and (right) 28-pin packages. (Courtesy Microchip Technology)

Table 1. Detailed of UV-Erasable PIC16C5X Microcontrollers
(Courtesy Microchip Technology)

Part #	EPROM	RAM	I/O**	Supply Voltage	Osc.Freq.Range	Package Options
PIC16C54	512 x 12	32 x 8	13	4.0* - 5.5 V	DC - 8 MHz ***	18 ld. Windowed CERDIP
PIC16C55	512 x 12	32 x 8	21	4.0* - 5.5 V	DC - 8 MHz ***	28 ld. Windowed CERDIP
PIC16C56	1K x 12	32 x 8	13	4.0* - 5.5 V	DC - 8 MHz ***	18 ld. Windowed CERDIP
PIC16C57	2K x 12	80 x 8	21	4.0* - 5.5 V	DC - 8 MHz ***	28 ld. Windowed CERDIP

* Frequencies above 4 MHz and/or operation in the industrial temperature range (-40 to +85°C) require that VDD is greater than 4.0 V (4.5 V or 4.75 V, see DC specs). The Low power (LP) versions operate at VDD range of 3.0 V to 5.5 V (see DC specs).

** Includes RTCC pin.

*** Device operation is currently guaranteed up to 8 MHz oscillator frequency. Please contact Microchip Technology Inc. for expected release dates of 20 MHz devices.

grammer to change the PIC firmware to execute the array of examples presented here. It's also a good idea to have the latest *Microchip Databook* and *Microchip Embedded-Control Handbook*, which you can obtain from Digi-Key or your local Microchip representative. These volumes provide everything technical you need to know about the full line of PICs and instructions on to how to access the Microchip BBS from which you can download various PIC tools and cross-assemblers. Since you'll be using Microchip base mnemonics to follow along in this article, you can easily reference them as they appear in the *Microchip Databook* listings.

To start this tutorial, I'll describe the features and advantages of the PIC16C5X series and compare them to other currently available microcontrollers.

Each PIC part includes a security EPROM fuse you can program to prevent anyone from reading the program code you've written to the on-board PROM or EPROM. If you use this feature to protect your ideas, be sure to program your code into the PIC *before* you program the code-protect fuse. Otherwise, activating code protection first will prevent you from entering and reading whatever code you plan on programming into the PIC. If you should make this error with an OTP PIC, there's nothing you can do but replace the PIC and start over with a new one. With an EPROM PIC, you can simply erase the device and start over again with the same PIC.

The differences in the four PIC16C5X devices are oscillator type, number of available I/O (input/output) pins and size of internal EPROM and RAM. An overview of the erasable PIC16C5X devices you'll be using is given in Table. 1.

In addition to being physically compact, the PIC comes with high-efficiency microcode (built-in programming)

Table 2. Complete Instruction Set for PIC16C5X Microcontrollers.

(Courtesy Microchip Technology)

BYTE -ORIENTED FILE REGISTER OPERATIONS

(11-6)	(5)	(4 - 0)
OPCODE	d	f(FILE #)

d = 0 for destination W
d = 1 for destination f

Instruction-Binary	(Hex)	Name	Mnemonic, Operands		Operation	Status Affected
0001 11df ffff	1Cf	Add W and f	ADDWF	f, d	W + f → d	C,DC,Z
0001 01df ffff	14f	AND W and f	ANDWF	f, d	W & f → d	Z
0000 011f ffff	06f	Clear f	CLRF	f	0 → f	Z
0000 0100 0000	040	Clear W	CLRW	-	0 → W	Z
0010 01df ffff	24f	Complement f	COMF	f, d	$\bar{f}$ → d	Z
0000 11df ffff	0Cf	Decrement f	DECF	f, d	f -1 → d	Z
0010 11df ffff	2Cf	Decrement f,Skip if Zero	DECFSZ	f, d	f - 1 → d, skip if zero	None
0010 10df ffff	28f	Increment f	INCF	f, d	f + 1 → d	Z
0011 11df ffff	3Cf	Increment f,Skip if zero	INCFSZ	f, d	f + 1 → d, skip if zero	None
0001 00df ffff	10f	Inclusive OR W and f	IORWF	f, d	W v f → d	Z
0010 00df ffff	20f	Move f	MOVF	f, d	f → d	Z
0000 001f ffff	02f	Move W to f	MOVWF	f	W → f	None
0000 0000 0000	000	No Operation	NOP	-	-	None
0011 01df ffff	34f	Rotate left f	RLF	f, d	f(n) → d(n+1), C → d(0), f(7) → C	C
0011 00df ffff	30f	Rotate right f	RRF	f, d	f(n) → d(n-1), C → d(7), f(0) → C	C
0000 10df ffff	08f	Subtract W from f	SUBWF	f, d	f - W → d [f + $\overline{W}$ + 1 → d]	C,DC,Z
0011 10df ffff	38f	Swap halves f	SWAPF	f, d	f(0-3) ↔ f(4-7) → d	None
0001 10df ffff	18f	Exclusive OR W and f	XORWF	f, d	W ⊕ f → d	Z

BIT- ORIENTED FILE REGISTER OPERATIONS

(11-8)	(7-5)	(4 - 0)
OPCODE	b(BIT #)	f(FILE #)

Instruction-Binary	(Hex)	Name	Mnemonic, Operands		Operation	Status Affected
0100 bbbf ffff	4bf	Bit Clear f	BCF	f, b	0 → f(b)	None
0101 bbbf ffff	5bf	Bit Set f	BSF	f, b	1 → f(b)	None
0110 bbbf ffff	6bf	Bit Test f,Skip if Clear	BTFSC	f, b	Test bit (b) in file (f): Skip if clear	None
0111 bbbf ffff	7bf	Bit Test f, Skip if Set	BTFSS	f, b	Test bit (b) in file (f): Skip if set	None

LITERAL AND CONTROL OPERATIONS

(11-8)	(7 - 0)
OPCODE	k (LITERAL)

Instruction-Binary	(Hex)	Name	Mnemonic, Operands		Operation	Status Affected
1110 kkkk kkkk	Ekk	AND Literal and W	ANDLW	k	k & W→ W	Z
1001 kkkk kkkk	9kk	Call subroutine	CALL	k	PC + 1 → Stack, k → PC	None
0000 0000 0100	004	Clear Watchdog timer	CLRWDT	-	0 → WDT (and prescaler, if assigned)	TO, PD
101k kkkk kkkk	Akk	Go To address (k is 9 bit)	GOTO	k	k → PC (9 bits)	None
1101 kkkk kkkk	Dkk	Incl. OR Literal and W	IORLW	k	k v W → W	Z
1100 kkkk kkkk	Ckk	Move Literal to W	MOVLW	k	k → W	None
0000 0000 0010	002	Load OPTION register	OPTION	-	W → OPTION register	None
1000 kkkk kkkk	8kk	Return,place Literal in W	RETLW	k	k → W, Stack → PC	None
0000 0000 0011	003	Go into standby mode	SLEEP	-	0 → WDT, stop oscillator	TO, PD
0000 0000 0fff	00f	Tristate port f	TRIS	f	W→ I/O control register f	None
1111 kkkk kkkk	Fkk	Excl. OR Literal and W	XORLW	k	k ⊕ W → W	Z

that requires only a 33-element, single-cycle, single-word instruction set to effect programs that normally require microcontrollers that use multiple-cycle, multiple-byte instruction sets. Each PIC16C5X instruction word is 12 bits in length, with the mnemonic opcode and operand (register, memory location or direct data to be manipulated) fully defined within the 12-bit word. All 33 PIC16C5X instructions are given in Table 2.

High-speed microcode execution is achieved in a PIC utilizing Harvard architecture, or the Harvard dual-bus concept, instead of the classic Von Neumann or single-bus implementation. Harvard architecture is register-file-based and has a separate bus and memory space allocated for instructions and data, which simply means that all program-con-

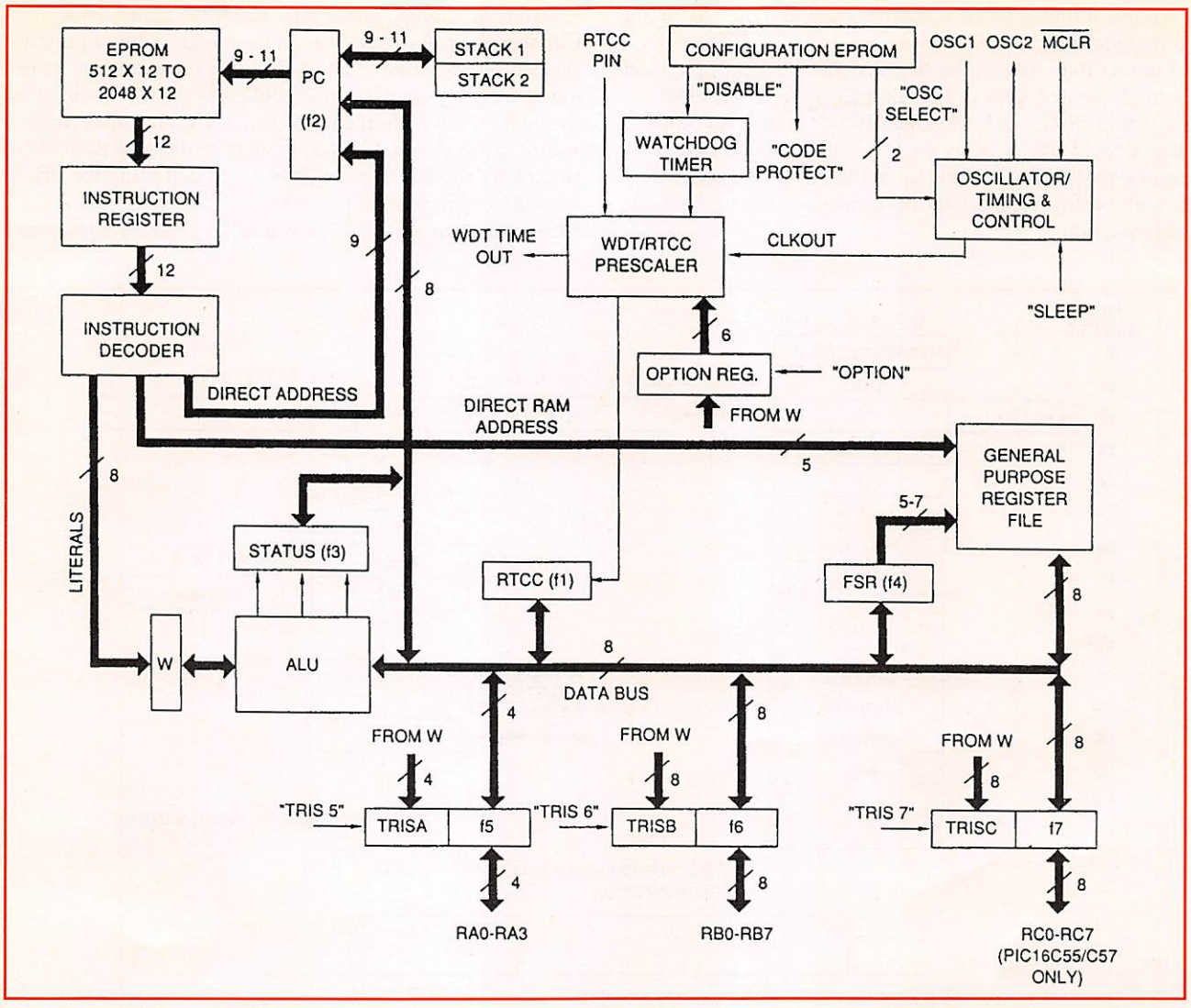


Fig. 2. Block diagram of PIC16C5X series. **(Courtesy Microchip Technology)**

trolled objects like I/O ports, memory locations and timers are physically implemented as hardware registers.

The PIC16C5X data memory (RAM) bus is eight bits in length, while the program memory (EPROM) bus is 12 bits in length. Using the Harvard dual-bus configuration permits the PIC to perform high-speed bit, byte and register operations. It also inherently permits overlapping instruction execution, known as pipelining. Pipelining is simultaneous execution of the current instruction as the next instruction is being read from program memory. Traditional Von Neumann architecture must fetch instruction and data information over a single shared (multiplexed) bus, which eliminates the ability to overlap instruction fetch and execution. Figure 2 is a block diagram of the dual-bus PIC16C5X.

As you can see, the internal logical and physical components that make up the PIC16C5X family are similar to any other microcontroller with which you may have previously worked. Thus, the PIC is no more difficult to program than any other microcontroller you may have programmed before. However, the way these common logical components, or objects, are interconnected via the dual-bus Harvard architecture within the PIC is the key to reduced compiled code count and high execution speed of the PIC16C5X family of microcontrollers.

Inside the PIC

Since all PIC program objects are actually implemented as physical registers within the PIC proper, to gain a better understanding of how PIC hardware works requires a more in-depth look at the PIC register file concept.

Within the PIC, the Operational Register File contains a means for indirect data addressing (f0), a real-time clock/counter (f1), a program counter (f2), a status-word register (f3), a file-select register (f4), and the I/O registers (f5 and f6 and sometimes f7). It's imperative that you understand the uses for these registers. As you can see in the data memory map shown in Fig. 3, these registers comprise the bulk of the user-manipulated hardware. Since this is a hands-on tutorial, I'll include some very simple and, hopefully, enlightening examples of how to apply each register, where possible. To be ready for the experiments that follow, though, first assemble the test circuit shown schematically in Fig. 4 on a solderless breadboarding socket.

Here's a lineup of the resources built into the Operational Register File:

• **Indirect Data Addressing Register (f0).** This isn't physically implemented. f0 uses the contents of the File Select Register (FSR), or f4, to indirectly select any one of the available 32 file registers for use as a data register or pointer register, depending upon the intent of the instruction that called f0. Register f0 is most useful as an indirect address pointer.

• **Real-Time Clock/Counter (f1).** The Real Time Clock/Counter, or RTCC, can be read from and written to just as you would any other register. The RTCC can also be incremented by an external signal applied to the RTCC pin or by the internal instruction clock. Obvious applications that would involve the RTCC are event counting and time measurement. The RTCC can also be prescaled using the PIC's internal programmable prescaler.

• **Program Counter (f2).** This is used to generate addresses

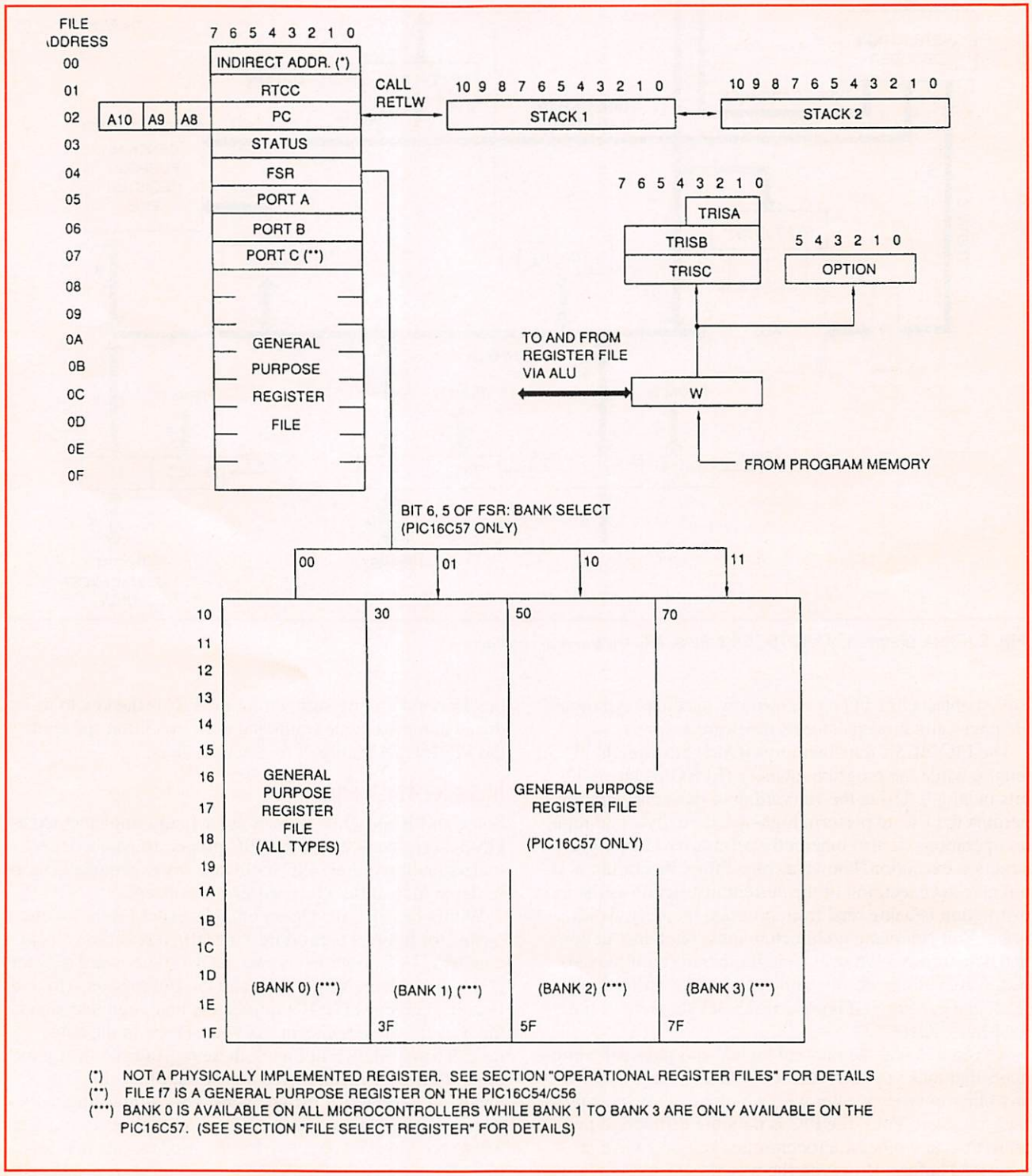


Fig. 3. Data memory map for PIC16C5X. **(Courtesy Microchip Technology)**

for EPROM cells that contain the 12-bit user written program instruction words. The PC is nine to 11 bits wide, depending on type of PIC. The tenth and eleventh bits of the PC come into play when you use the paging capabilities of the EPROM-rich PIC16C56 and PIC16C57 devices, thus permitting PIC programs up to 2,048 words in length. A two-word stack area is provided for call and return operations.

• **Status Word Register (f3).** Arithmetic status of the ALU (carry bit, zero bit, etc.), RESET status and page preselect bits for the larger program memories of the PIC16C56/57 are contained within this register. f3 is comparable to the PSW (Program Status Word) found in most other microprocessors. An interesting quirk to keep in mind is that register f3 provides a general-purpose read/write bit that's reserved for future use but can be freely used by the programmer. Power-down and time-out bits used by the Watchdog Timer (WDT) and sleep instructions are also held in f3.

• **File Select Register (f4).** As previously noted, File Select Register, or FSR f4, is used in conjunction with Indirect Data Addressing Register f0 to indirectly select one of 32 available file registers. Since only Bit 0 through Bit 4 are utilized to select registers f0 through f1F (addressed 0 through 1F hexadecimal), Bits 5, 6 and 7 of FSR are read-only and are always set to binary 111. If no indirect calls are used in the program, this register can serve as a five-bit-wide general-purpose register.

• **I/O Registers (f5 through f7).** Ports A (f5), B (f6) and C (f7), comprise the I/O registers for the PIC16C55 and PIC16C57. Port C (f7), is a general-purpose register on the PIC16C54 and PIC16C56 not enough pins exist on these devices to accommodate another physical I/O port. Port A is a four-bit I/O register, with Bits 4 through 7 defined as binary 0000. Ports B and C are full eight-bit implementations. These I/O registers can be read from and written to just like any other registers in the register file and are capable of having related I/O pins placed in high-impedance state for isolation or read operations. Any I/O pin can be independently programmed for input, output or bidirectional operation.

• **General-Purpose Registers.** The second set of registers, known as the General-Purpose Registers, is defined as f08 through f1F (addressed 08 through 1F hex) for the PIC-16C54, PIC16C55 and PIC16C56. Referring to Fig. 3, you'll note that the PIC16C57 extends General Purpose Register presence to f7f (addressed 7F hex) via bank switching. General Purpose Registers are most commonly used as internal user RAM.

• **Special-Purpose Registers.** To close out this look at the PIC16C5X register file, I'll briefly explore such Special Purpose Registers as the W, or Working Register, which is essentially an accumulator. W is used heavily for internal data-transfer operations. Three other write-only I/O control Special Purpose Registers—TRISA, TRISB and TRISC—determine if the bits in the corresponding Port registers (Ports A, B and C). Thus, their respective I/O pins are input or output. Note that the PIC16C54 doesn't utilize Port C and implements it as a general-purpose register. A binary 1 corresponds to high-impedance or input mode, while a binary 0 allows output of that bit position to the related I/O pin. For example, W is loaded with binary

00001111 and TRISB is executed. The result would be that Port B (f6) would hold Bits 0 through 3 at high impedance (input state) and output the contents of register f6 Bits 4 through 7 to the I/O pins.

• **Option Register.** This is the last of the Special Purpose Registers. It defines prescaler assignment to the RTCC or WDT. The prescaler is shared by RTCC and WDT in a mutually-exclusive assignment. Only one resource can be prescaled at a time. Other bits within the register determine on which signal edge RTCC will clock and if the RTCC input signal is internally or externally generated.

• **Watchdog Timer.** This is used to prevent catastrophic software crashes from stopping a PIC program from running. It can also be used in timing applications, somewhat like a missing-pulse detector. The idea behind watchdog timers is to reset the watchdog timer under software control internally or via an external event before the watchdog timer can time-out and generate a processor reset. Therefore, if the program is operating normally, the built-in commands to reset the watchdog timer (CLRWDT) would be executed within specified time limits, eliminating a processor reset. On the other hand, if the microprocessor leaped beyond the existing program or began to loop within the program, the watchdog timer reset commands most likely wouldn't be executed in a timely manner, a watchdog time-out would occur and a full-blown processor reset would be issued to clear the error condition, and, hopefully, the program would again run normally.

The PIC16C5X watchdog timer doesn't require external components and operates on its own internal RC oscillator. WDT operates even if the main processor clock isn't operational. Typical WDT time-out period is 18 ms. The prescaler can be assigned to WDT and extend the time-out period to beyond 2 seconds.

Another function of the WDT is to aid wake-up operations during the PIC16C5X sleep mode. The instruction SLEEP puts the PIC into sleep mode. When the PIC-16C5X sleeps, very little power is consumed. Sleep mode can be exited on the occurrence of an event, such as the activation of a switch or sensor.

• **Oscillator Options.** There are four oscillator options you can use with the PIC16C5X series of microcontrollers: XT, which is a crystal oscillator; HS, which is a high-speed crystal oscillator; LP, which is a low-power crystal oscillator; and RC, which is an RC-network oscillator.

OTP devices can be purchased with any one of the oscillator configurations pre-programmed. EPROM devices can be programmed to use any of the four oscillator configurations. XT, HS and LP devices need a ceramic resonator, crystal or buffered external clock source to establish oscillation, while the RC configuration requires only a resistor and capacitor. Naturally, ceramic resonator and crystal oscillator configurations are more accurate time-keeping devices, but if high-accuracy timing isn't required in a given application, the RC oscillator approach can be used to cut cost and circuit complexity.

• **Reset Circuitry.** PIC16C5X devices use an internal Power On Reset (POR) circuit in conjunction with the Oscillator Start-Up Timer (OST) to alleviate the need for the traditional reset capacitor and resistor in most situations. To use the POR circuitry, you need only tie the MCLR pin to +5 volts. If the power ramps up slowly or you're operating

Listing 1. Programming Code For PC Tutor Header Only

```
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
; PIC TUTOR ... HEADER ONLY                                                 ;
;                                                                           ;
; E D TECHNICAL PUBLICATIONS                                                ;
;                                                                           ;
; REVISION 02-21-94                                                         ;
;                                                                           ;
; MICROCOMPUTER JOURNAL                                                     ;
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;


;********* PIC16C54 BASE EQUATES
;
;
;
RTCC          EQU    1H      ;REGISTER ASSIGNMENTS
PC            EQU    2H
STATUS        EQU    3H
FSR           EQU    4H
;
CNTRLPORT     EQU    5H
DATAPORT      EQU    6H      ;I/O PORT ASSIGNMENTS
;
;
;
;********* PIC16C54 STATUS REGISTER EQUATES
;
;
C             EQU    0H
DC            EQU    1H
Z             EQU    2H
PD            EQU    3H
TO            EQU    4H
PA0           EQU    5H
PA1           EQU    6H
PA2           EQU    7H

;********* DL-1414 EQUATES
;
WELOW         EQU    2H      ;BIT 2 OF PORT_A (RA2) WE FOR LOW NIBBLE
WEHI          EQU    3H      ;BIT 3 OF PORT_A (RA3) WE FOR HIGH NIBBLE

_A1           EQU    1H      ;BIT 1 OF PORT_A DL-1414 ADDRESS A1
_A0           EQU    0H      ;BIT 0 OF PORT_A DL-1414 ADDRESS A0

;********* PIC16C54 REGISTER EQUATES
;
SCRATCH       EQU            7H
DIGIT         EQU            8H
```

with a very slow clock speed, the typical RC reset circuit can be used.

Programming Code

Having covered the hardware details of the PIC, let's write some short code and exercise the hardware on the breadboarded circuit. In this segment, you'll be applying all 33 instructions. To do so, in addition to the hardware, you need a PIC assembler. You can use the Microchip version or any other PIC assembler that generates base Microchip

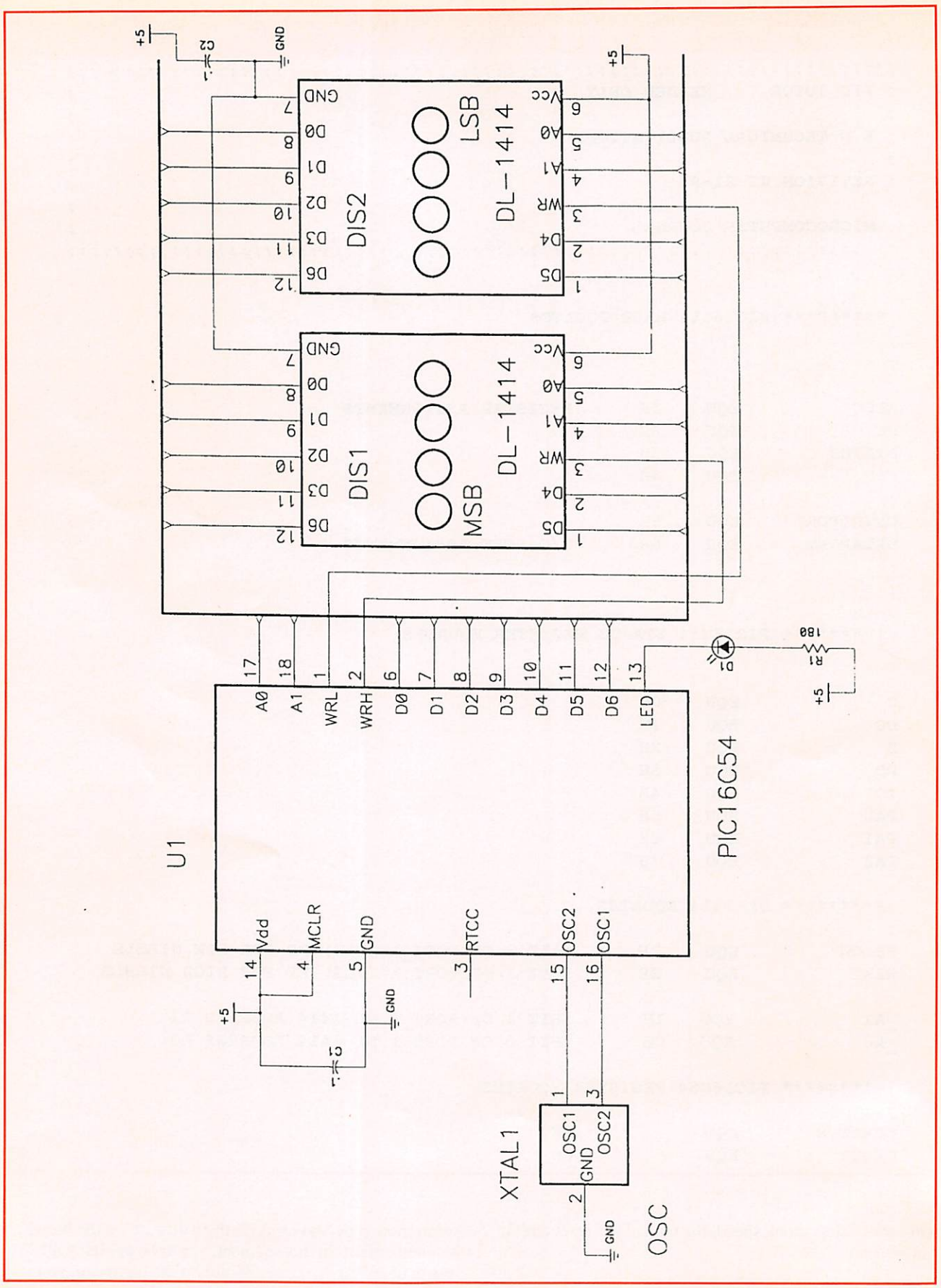


Fig. 4. Assemble this circuit on solderless breadboarding socket to conduct experiments detailed in text.

opcode. An assembler is a piece of software that normally runs on your PC to compile and translate source code like that shown in Listing 1 into binary data (opcode) the PIC can understand and use. Source code is written with an ASCII editor and is the human perception of the final opcode. You'll name an entity in the source code that makes sense to you but makes absolutely no sense to the PIC without being translated in the assembly process.

In the Fig. 4 circuit, a PIC16C54 drives two DL-1414 intelligent displays using a 4-MHz clock. A LED and associated current-limiting resistor can be tied to the vacant pin to facilitate demonstration of bit-oriented instructions. The LED arrangement is an added attraction of the PIC. Each PIC I/O pin can sink enough current to drive a LED, eliminating the need for a separate driver transistor and associated resistors. The displays keep you informed of program results in binary format, with *DIS2* being the lower nibble and *DIS1* being the upper nibble (a "nibble" consists of four bits).

Begin experimenting by examining the skeleton code that must be used with your examples. When you start writing code for your own PIC projects, the header portion (all code preceding the ORG 0 statement) of our skeleton code will take on the look of the needs of your application. The header code defines resources by allowing you to specify logical names for bit positions, ports and registers. Your header code sets up the I/O pins so that Ports A and B are configured as outputs, which makes sense here because you're driving only DL-1414 input pins. When the PIC16C54 powers up, all I/O defaults to input and processing begins at address 1FFH. Where applicable, use comments in the code to simplify some of the explanations. The skeleton code is outlined in Listing 1.

Refer back to Fig. 3 as you step through the contents of the skeleton code. First of all, note that anything following a ";" (semicolon) is considered to be a comment. The RTCC statement instructs the PIC assembler to substitute a 1H (hex) every time RTCC is encountered. EQU means equate. Thus, you've equated RTCC to 1H. Notice in Fig. 3 that RTCC is actually file Address 01. You could use 01H every time you want to address the RTCC register, but your code would be more-difficult to debug because you'd have to remember that 01H represents RTCC. You could have numerical data that must be represented as 01H as well. Using the equates to name resources eliminates ambiguity and makes for easier source-code reading. You can see the relationship by examining the PC, STATUS and FSR definitions. The PC name relates to file Address 02, the STATUS name to file address 03, FSR to file Address 04, etc. I've also named the I/O ports, CNTRLPORT (5) and DATAPORT (6). General-purpose registers can be named as well. I've chosen to call general-purpose register 07 "SCRATCH" and general-purpose register 08 "DIGIT."

As you step through this tutorial, you'll see that you don't use the PC directly, though it's defined. Keep in mind that you can define equates and not use them, but you can't use an equate you haven't previously defined.

Not only can you name or "equate" registers, you can do the same for bits inside registers. Take a look under the status register equates section. Figure 5 is a layout of the Status Word Register. Note that C is equated to 0H because C (CARRY) is in bit position 0 of the Status Word. Following the skeleton code on down, you'll see the pattern, bit for bit. So, every time you need to check CARRY Bit 0, you can use the pre-defined equate C. Every time you want to access Bit 2, or the ZERO bit, you use the character "Z" instead of 02H. You can define an entire register's bit structure, even if you don't use it all. I've done a similar operation on the I/O port pins, equating them to names that logically connect to the DL-1414 pins they serve.

At this point, you should have a good handle on equate statements. Let's now move on to the executable code area. Before you get there, though, you must cross an ORG 0 statement. This is a locator for the assembler. For the person who entered it, this assembler instruction simply states that the code following this ORG statement begins at EPROM memory location 0. This statement instructs the assembler to being addressing (counting) at address or location 0H from the following statement onward.

The ORG statement is used to place code at a particular address within the EPROM's memory space. Another example of the ORG directive in our code is the ORG 1FFH statement near the end of the skeleton code. As previously stated, the PIC16C54 begins program execution at this address (1FFH). The instruction immediately following ORG 1FFH is GOTO BEGIN, which directs the program to jump to the label BEGIN and is, in fact, address 0, as defined by the ORG 0 directive. Directive END notifies the assembler that no executable code lies beyond its boundary.

You've now established the beginning of real program execution at address 1FFH. The first instruction executed in the code is GOTO BEGIN, which jumps to location 0 and resumes execution there. BEGIN is a user-selected name or label (labels always start at the left margin) the assembler uses as an address reference. During the assembly process, the assembler notes the location of BEGIN and remembers that when it sees BEGIN again in the source code to automatically substitute the address BEGIN represents when calculating jumps and calls. The GOTO and CALL instructions use these labels as references in the source code. Thus, you can jump immediately to the address represented by BEGIN by executing GOTO BEGIN or calling a subroutine marked by the START label by issuing CALL START. Labels are especially useful for implementing loops and subroutines. If you've programmed in BASIC, this is the same label you've used and know so well.

Now that the assembler is informed as to the "logical human language" you'll be using in your PIC source code and knows where to begin and where to convert labels to addresses, let's look at some code in the PIC skeleton the PIC itself will execute. The first instruction following the BEGIN label, MOVLW B'00000000', loads the W register with hexadecimal 00H. The B' indicates the data that follows is in binary format. I could have written MOVLW 0 (decimal) or MOVLW 0H (hex) and accomplished the same thing. Using the binary representation, especially when manipulating bits within a register, eliminates having to get out the hex calculator to interpret bit positions.

Remember, your aim is to define the I/O ports as outputs. The next two instructions, TRIS CNTRLPORT and TRIS DATAPORT, write 0s to the internal port-control latches of Ports 5 and 6, which I equated as CNTRLPORT and DATAPORT, respectively, and force the affected port

Listing 2. Complete Programming Code for PC Tutor

```
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
; PIC TUTOR                                                               ;
;                                                                         ;
; E D TECHNICAL PUBLICATIONS                                              ;
;                                                                         ;
; REVISION 02-21-94                                                       ;
;                                                                         ;
; MICROCOMPUTER JOURNAL                                                   ;
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;


;********* PIC16C54 BASE EQUATES
;
;
;
RTCC            EQU      1H                      ;REGISTER ASSIGNMENTS
PC              EQU      2H
STATUS          EQU      3H
FSR             EQU      4H
;
CNTRLPORT       EQU      5H
DATAPORT        EQU      6H                      ;I/O PORT ASSIGNMENTS
;
;
;
;********* PIC16C54 STATUS REGISTER EQUATES
;
;
C               EQU      0H
DC              EQU      1H
Z               EQU      2H
PD              EQU      3H
TO              EQU      4H
PA0             EQU      5H
PA1             EQU      6H
PA2             EQU      7H

;********* DL-1414 EQUATES
;
WELOW           EQU      2H                      ;BIT 2 OF PORT_A (RA2) WE FOR LOW NIBBLE
WEHI            EQU      3H                      ;BIT 3 OF PORT_A (RA3) WE FOR HIGH NIBBLE

_A1             EQU      1H                      ;BIT 1 OF PORT_A DL-1414 ADDRESS A1
_A0             EQU      0H                      ;BIT 0 OF PORT_A DL-1414 ADDRESS A0

;********* PIC16C54 REGISTER EQUATES
;
SCRATCH         EQU      7H
DIGIT           EQU      8H

;********* MAIN PROGRAM

                ORG      0
BEGIN
                MOVLW    B'00000000'             ;LOAD W WITH 00 HEX
                TRIS     CNTRLPORT               ;MAKE RA0-RA3 PORT PINS OUTPUTS
                TRIS     DATAPORT                ;MAKE RB0-RB7 PORT PINS OUTPUTS

                MOVLW    B'00001100'             ;SET WELOW AND WEHI
                MOVWF    CNTRLPORT               ;CLEAR RA0 AND RA1


           ;
           ;

           ;INSERT EXAMPLE CODE HERE
           ;
           ;
```

```
DISPLAY
        MOVWF   DIGIT                   ;LOAD DIGIT WITH RESULT

        MOVLW   04H                     ;LOAD SCRATCH REGISTER WITH 4
        MOVWF   SCRATCH                 FOR DIGITS 0-3 (4 BITS)


NEXTDIGITL
        RRF     DIGIT,1                 ;ROTATE LSB INTO CARRY
        BTFSC   STATUS,C                ;TEST CARRY FOR 1 OR 0
        GOTO    ITIS1L

        MOVLW   30H                     ;IT IS A 0. GO WRITE A ZERO
        MOVWF   DATAPORT                ;LOAD DATA TO DISPLAY DATA BUS
        GOTO    WRITEITL
ITIS1L
        MOVLW   31H                     ;IT IS A 1...GO WRITE A ONE
        MOVWF   DATAPORT                ;LOAD DATA TO DISPLAY DATA BUS
WRITEITL
            BCF     CNTRLPORT,WELOW     ;WRITE BY CLEARING WELOW
            NOP                         ;WAIT 1uS (WAY LONG, BUT OK)
            BSF     CNTRLPORT,WELOW     ;END WRITE BY SETTING WELOW

            DECFSZ SCRATCH,1            ;DECREMENT THE BIT COUNTER
            GOTO                        NEXTADDL
            GOTO                        DISPLYHI
NEXTADDL
            INCF    CNTRLPORT,1         ;INCREMENT THE ADDRESS
            GOTO    NEXTDIGITL          ;GO GET NEXT DIGIT FOR LOW NIBBLE

DISPLYHI
            MOVLW   4H                  ;LOAD SCRATCH REGISTER WITH 4
            MOVWF   SCRATCH             ;FOR DIGITS 4-7 (4 BITS)
            MOVLW   00001100B           ;RESTORE THE DISPLAY ADDRESS TO 0
            MOVWF   CNTRLPORT

NEXTDIGITH
            RRF     DIGIT,1             ;ROTATE LSB INTO CARRY
            BTFSC   STATUS,C            ;TEST CARRY FOR 1 OR 0
            GOTO    ITIS1H
            MOVLW   30H                 ;IT IS A 0. GO WRITE A ZERO
            MOVWF   DATAPORT            ;LOAD DATA TO DISPLAY DATA BUS
            GOTO    WRITEITH
ITIS1H
            MOVLW   31H                 ;IT IS A 1...GO WRITE A ONE
            MOVWF   DATAPORT            ;LOAD DATA TO DISPLAY DATA BUS
WRITEITH
            BCF     CNTRLPORT,WEHI      ;WRITE BY CLEARING WELOW
            NOP                         ;WAIT 1uS (WAY LONG, BUT OK)
            BSF     CNTRLPORT,WEHI      ;END WRITE BY SETTING WELOW

            DECFSZ  SCRATCH,1           ;DECREMENT THE BIT COUNTER
            GOTO    NEXTADDH

          GOTO    DONE
NEXTADDH
            INCF    CNTRLPORT,1         ;INCREMENT THE ADDRESS
            GOTO    NEXTDIGITH          ;GO GET NEXT DIGIT FOR LOW NIBBLE

DONE
            GOTO    $                   ;STAY HERE FOREVER..UNTIL POWER OFF


            ORG     1FFH
            GOTO    BEGIN               ;PIC16C54 STARTUP VECTOR

            END
```

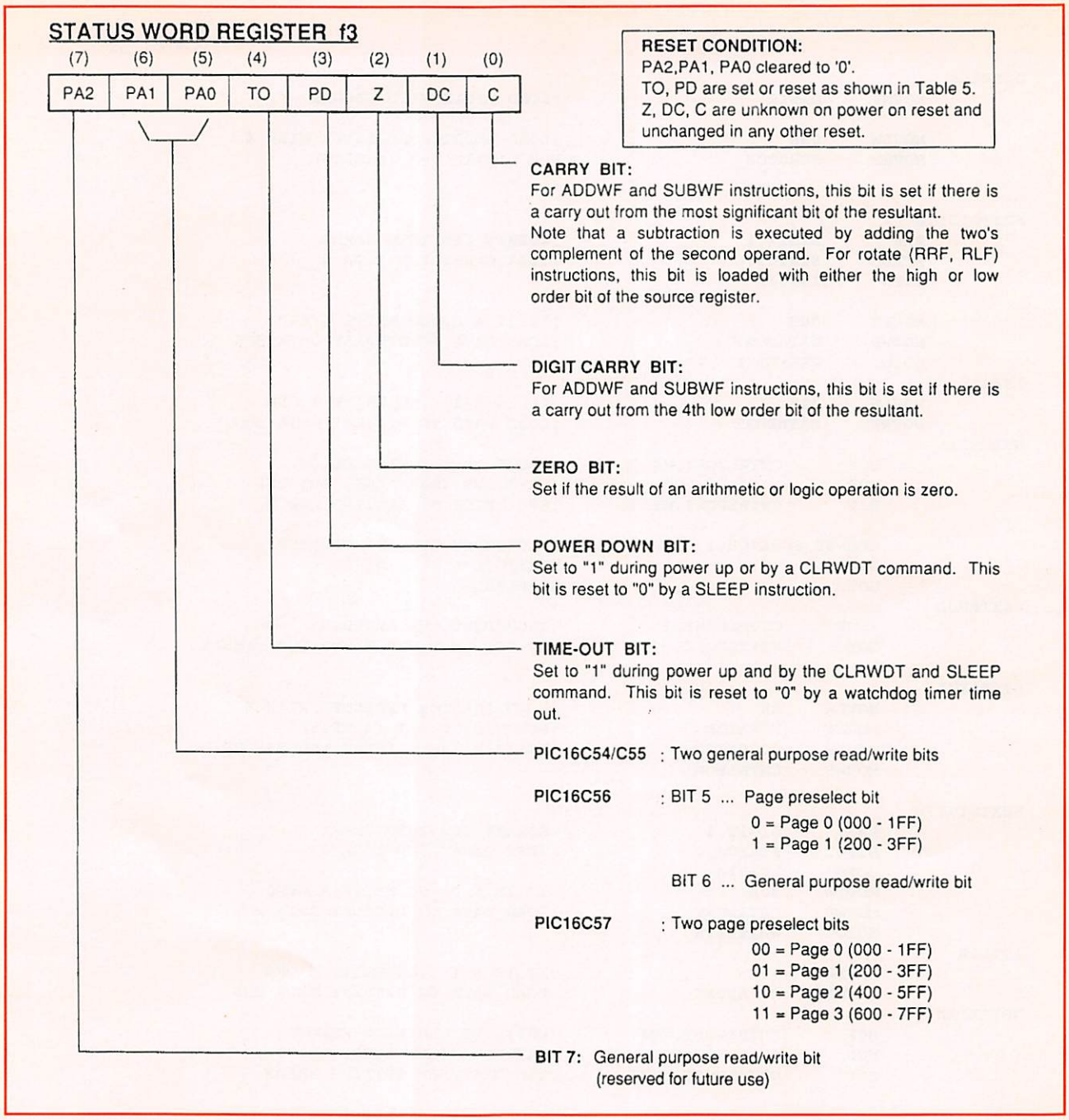


Fig. 5. Layout of Status Word Register. (Courtesy Microchip Techlology)

pins to output state. In this case, all I/O port pins are affected and set to output state. Note that PORTA is a four-bit port and uses only the least-significant four bits and discards the most-significant four bits of the W register.

For the purposes of the PIC, least-significant Bit 0 is located at the far right of the MOVLW B'00000000' instruction, with the most-significant bit being at the far left. You'll sometimes see these bit locations referenced as LSB (least-significant bit) and MSB (most-significant bit).

As an aside, if you wanted to make all I/O ports input ports, the instruction would be MOVLW B'11111111'. You can mix and match outputs and inputs when using the TRIS instruction. For instance, to make PORTB Bit 7 (RA7) the sole input, you'd issue MOVLW B'10000000', followed by TRIS DATAPORT. Bit 7 (RA7) is the MSB of Port B.

Once you've completed setup of the initial I/O port, you can write to the ports and either set (write a 1) or clear (write a 0) individual bits on the I/O ports. In this tutorial hardware, you must clear RA0 and RA1 and set RA2 and RA3. Essentially, you want to set the DL-1414 address to 0 and inhibit both DL-1414 write-enable pins by setting them to TTL high (logical 1). You accomplish this by loading W with binary 00001100 with the MOVLW in-

struction and moving the binary pattern contained in W to the Port A or CNTRLPORT pins using the MOVWF CNTRLPORT instruction. At this point, the DL-1414 displays are inactive and are prepared for display activity.

You're now at a point at which you can insert the example code between the header and footer in the skeleton you've defined. Notice the commented line INSERT EXAMPLE CODE HERE. You'll replace this comment with actual instructions and note their results where applicable on the display or by the condition of the LED tied to the RB7 I/O pin.

If you know little about PIC assembly language, any attempt to explain the code that drives the intelligent displays would be like putting the cart before the horse. So, Listing 2 provides the complete skeleton code listing that you'll understand when you've completed your tour through the entire PIC16C5X instruction set.

The Instruction Set

Now let's look at each of the PIC's 33 programming instructions in turn.

• ***NOP.*** You really can't show results of the NOP instruction because it does nothing. NOP is PIC-ese for No OPeration. This instruction is useful when fine-tuning timing loops because it does take up a cycle but affects nothing else.

• ***MOVLW; MOVWF f,d; GOTO.*** These have already been examined in the header of the skeleton code. MOVLW simply loads a literal, or constant value, into W. MOVWF, moves an eight-bit value from W to a designated register (f), as depicted in the instruction set summary. The d operand directs the result of the operation to the W register when d=0 , or the register the instruction is working with (f) when d=1. This use of the d operand is followed throughout the instruction set.

The following source code writes the binary pattern 01010101 to the W register and then moves the contents of Register W to Port B. Use a logic probe to test each pin of Port B (RB0 through RB7) and note the pattern.

```
MOVLW     B'01010101'     ;LOAD W WITH BINARY 01010101
MOVWF     DATAPORT        ;WRITE W TO PORT B (DATAPORT)
GOTO      $               ;LOOP HERE FOREVER
```

The GOTO instruction is a control operation. Directive $ means current PC (Program Counter). Thus, the statement GOTO $ says jump to where you currently are. Therefore, the loop is infinite. This combination of $ directive and GOTO instruction is most useful for stopping your code during debugging.

• ***CLRW.*** This instruction clears the W register to 0H. Let's simply add a line to the code we already have to illustrate this one:

```
MOVLW     B'01010101'     ;LOAD W WITH BINARY 01010101
CLRW                      ;CLEAR W TO 0H
MOVWF     DATAPORT        ;WRITE W TO PORT B (DATAPORT)
GOTO      $               ;LOOP HERE FOREVER
```

You should see TTL lows on all pins of Port B when you implement this code.

• ***CLRF f.*** This does for registers what CLRW does for W. The following sets port B to 0H:

```
CLRF      DATAPORT        ;CLEAR PORT B (DATAPORT)
```

• ***SUBWF f,d; ADDWF f,d.*** Subtract W from general-purpose Register f. This instruction also affects the CARRY, DIGIT CARRY, and ZERO bits in the Status Word Register. Examination of these bits following execution of this instruction enables you or the program to determine if the result is 0, negative, or positive. Our example loads the SCRATCH register (General Purpose Register 7) with FFH and loads the W register with 1H. SUBWF is then executed, and the result is directed to the W register and displayed on the DL-1414 displays.

```
MOVLW     0FFH            ;LOAD W WITH FFH
MOVWF     SCRATCH         ;LOAD W CONTENTS TO SCRATCH
MOVLW     01H             ;LOAD W WITH 01H
SUBWF     SCRATCH,0       ;EXECUTE SUBTRACT
```

The display should be 11111110.

ADDWF is the opposite instruction and behaves just as the subtract instruction does when it comes to status bits.

```
MOVLW     0H              ;LOAD W WITH 0
MOVWF     SCRATCH         ;LOAD W CONTENTS TO SCRATCH
MOVLW     1H              ;LOAD W WITH 1
ADDWF     SCRATCH,0       ;EXECUTE ADD INSTRUCTION
```

This results in a displayed value of 00000001.

Note that a 0 precedes the FFH in the operand portion of the MOVLW instruction in the SUBWF code segment. The 0 tells the assembler that this is intended to be a real number, not a label. Otherwise, the assembler would be looking for the label FF. In this, case it doesn't exist and an assembly error would occur. The H following the OFF operand indicates the value is in hexadecimal format.

• ***DECF f,d; INCF f,d.*** DECF decrements a register by 1 while INCF increments a register by 1. The result can be placed back into the original register or directed to the W register. The following code results in the same bit pattern obtained when you ran the SUBWF instruction, but only the ZERO bit is affected.

```
MOVLW     0FFH            ;LOAD W WITH FFH
MOVWF     SCRATCH         ;LOAD W CONTENTS TO SCRATCH
DECF      SCRATCH,0       ;EXECUTE DECREMENT SCRATCH
```

This code segment increments SCRATCH from 0 to 1:

```
CLRF      SCRATCH         ;CLEAR SCRATCH
INCF      SCRATCH,0       ;INCREMENT SCRATCH
```

• ***IORWF f,d; ANDWF f,d; XORWF f,d.*** These instructions represent the Inclusive-OR, AND and Exclusive-OR file-register functions of the PIC code set. Inclusive-OR is useful when setting multiple bits within registers. These same bits can then be reset by executing the ANDWF instruction. When like bits are Exclusive-ORed, the result is 0. Hence, the Exclusive-OR function is often used to test the condition (set or cleared) of a set of bits within a register.

The following example code uses the IORWF instruction to turn off the LED and the ANDWF function to turn it on.

```
CLRF      DATAPORT        ;ZERO PORT B (TURN ON LED)
MOVLW     B'10000000'     ;SET UP MASK IN W
IORWF     DATAPORT,1      ;OR W WITH DATAPORT (LED OFF)
GOTO                      ;LOOP HERE FOREVER
```

In defining the term MASK, mask is simply a pattern of bits that will be logically combined with another bit pattern.

Now turn on the LED using the ANDWF instruction with the following code:

```
MOVLW     B'11111111'     ;LOAD W WITH FFH
MOVWF     DATAPORT        ;SET DATAPORT BITS (LED OFF)
CLRW                      ;CLEAR W REGISTER TO 0
ANDWF     DATAPORT,1      ;CLEAR DATAPORT BITS (LED ON)
GOTO      $
```

Assume you've incremented the SCRATCH register and would like to know if you've reached 04H. Here's a good place to employ the IORWF instruction:

```
MOVLW     04H             ;LOAD W 04H
MOVWF     SCRATCH         ;LOAD SCRATCH WITH 04H
XORWF     SCRATCH,0       ;XOR W AND SCRATCH
```

Since SCRATCH was, indeed, 04H, the result of Exclusive-OR was 0. You see binary 0000000 in the displays, and the ZERO status bit has been set. A real-world program would probably check the ZERO status bit and determine how to proceed from there.

• ***IORLW k; ANDLW k; XORLW k.*** These logical operators operate like their file-register counterparts, except that the operation is always a constant operand used against the W register. Think of k as a mask and W as a target of the mask. For instance:

```
MOVLW     0FFH            ;LOAD W WITH FFH
ANDLW     0               ;AND 0 WITH W
```

The result is 00000000 in the displays.

```
MOVLW     00H             ;LOAD W WITH 0
IROLW     0FFH            ;OR W WITH FFH
```

This results in 11111111 in the displays.

```
MOVLW     B'00100000'     ;LOAD W WITH 40H
XORLW     B'11111111'     ;XOR W WITH DFH
```

This result will show 11011111 in the displays.

You can see that these instructions perform the exact same operations as their brothers, but in a more direct way.

• ***MOVF f,d.*** This is a unique instruction. It's used mainly to move general-purpose register contents to the W register. It can also be used to test a general-purpose register for 0 by setting d to 1, which loads the register with itself. With the following, you load the SCRATCH register with 0FH and then load the W register with the contents of the SCRATCH register and display the contents of the W register on the DL-1414 displays:

```
MOVLW     0FH             ;LOAD W WITH 0FH
MOVWF     SCRATCH         ;LOAD SCRATCH WITH 0FH
CLRW                      ;ZERO W
MOVF      SCRATCH,0       ;LOAD W WITH SCRATCH
```

If you wanted to test the SCRATCH register for zero during execution of a program, you could execute the following instruction:

```
MOVF      SCRATCH,1
```

The ZERO bit of the status word would be set if the condition was met (SCRATCH = 0H).

• ***COMF f,d.*** The complement of 1 is 0 and vice-versa. This is what this instruction does, complements bits within a register. To illustrate this, you complement the binary pattern 01010101 and note the result in the displays as follows:

```
MOVLW     B'01010101'     ;LOAD W WITH PATTERN
MOVWF     SCRATCH         ;LOAD SCRATCH WITH W
COMF      SCRATCH,0       ;COMPLEMENT SCRATCH
```

The pattern displayed should be binary 10101010.

• ***DECFSZ f,d; INCFSZ f,d.*** As you become more familiar with PIC assembly language, you'll find yourself using these two instructions most often. DECFSZ, decrement f (register) and skip next instruction if 0, and INCFSZ, increment f and skip next instruction if 0, are used to implement timing loops, counters, software clocks, delay loops and baud rates for serial communication. A typical loop follows:

```
START
          MOVLW     0FFH            ;LOAD W WITH FFH
          MOVWF     SCRATCH         ;LOAD SCRATCH WITH W
          CLRF      DATAPORT        ;TURN ON LED
LOOP
          DECFSZ    SCRATCH,1       ;DECREMENT SCRATCH
          GOTO      LOOP            ;SKIP IF SCRATCH = 0
          MOVLW     80H             ;LOAD W WITH 80H
          MOVWF     DATAPORT        ;TURN OFF LED
          GOTO      START           ;GO DO IT OVER
```

The LED will be flashing too fast for you to follow. So you may want to use a logic probe or oscilloscope to monitor I/O pin RB7.

Note the use of labels here. The actual loop begins at the LOOP label and ends at the instruction GOTO LOOP. The LED is on during the loop sequence and is turned off by setting the MSB of Port B following the loop. GOTO START directs the program to repeat itself forever. "Forever" in the world of the PIC is as long as power is present. You can use the same code and work with the INCFSZ instruction. Since you'll be incrementing, you should load SCRATCH with 0H. As you have by now probably figured out, the registers simply roll over. Increment a register that contains FFH and the result is 00H. Decrement a register that contains 00H and end up with FFH.

• ***SWAPF f,d.*** This instruction simply swaps nibbles within a register. A nibble is four bits, a byte is eight bits. The following example code is self-explanatory:

```
MOVLW     B'00001111'     ;LOAD W WITH 0FH
MOVWF     SCRATCH         ;LOAD SCRATCH WITH 0FH
SWAPF     SCRATCH,0       ;SWAP NIBBLES
```

Your displays should indicate 11110000.

• ***RRF f,d; RLF f,d.*** The rotate instructions consist of RRF, rotate register right through CARRY and RLF, rotate register left through CARRY. Rotate instructions are sometimes used to multiply by shifting, or rotating left, or dividing by rotating right. RRF and RLF are also useful in assisting the bit-by-bit transfer required in serial routines. Study usage of them in your display routine in the skeleton code. In either case, the bit shifted out of the eight-bit register is passed to the CARRY bit in the status word, and the CARRY bit is shifted in on either end, depending on the

direction of rotate. CARRY is shifted into the LSB on an RLF and shifted into the MSB after an RRF.

```
BCF     STATUS,C    ;CLEAR THE CARRY BIT
MOVLW   0FFH        ;LOAD W WITH FFH
MOVWF   SCRATCH     ;LOAD SCRATCH WITH FF
RRF     SCRATCH,1   ;ROTATE LSB OUT
```

Your display should read 01111111, since CARRY rotated into the MSB.

Now rotate left with the following:

```
BCF     STATUS,C    ;CLEAR THE CARRY BIT
MOVLW   0FFH        ;LOAD W WITH FFH
MOVWF   SCRATCH     ;LOAD SCRATCH WITH FF
RLF     SCRATCH,1   ;ROTATE MSB OUT
```

This should result in 11111110 in the displays.

• ***BCF f,d.; BSF f,d.*** Bit clear f BCF and bit set f BSF are used to set or clear individual bits within a register. These aren't difficult to use or understand. Turn on the LED using BCF as follows:

```
MOVLW   0FFH        ;LOAD W WITH FFH (LED OFF)
MOVWF   DATAPORT    ;TURN LED OFF
BCF     DATAPORT,7  ;CLEAR BIT 7 OF DATAPORT
GOTO    $
```

The result is turning on the LED by toggling a single bit. Remember, you did the same thing using a mask and the ANDWF instruction. The difference is that you needed to affect only a single bit in a single operation, whereas the ANDWF could affect multiple bits in a single operation. Also, the bit set/clear functions don't affect the Status Word Register. Thus, bit set and clear instructions are commonly used to effect a result that doesn't require a status-bit check. Bit set and clear functions can be used following a status-bit check to complete a logical operation, such as turning on an LED with a counter reaches 0. Substitute BSF for BCF in the above code segment. I think you already know what will happen.

• ***BTFSC f,b; BTFSS f,b.*** Introducing the bit-test commands. BTFSC, or bit test f and skip if bit is clear, and BTFSS, bit test f skip if bit is set, test a bit within a register and either skip or execute the following instruction, depending on the state of the bit tested. These instructions find their way into keyboard input programs, communication routines and sensor applications. For instance, suppose you were watching the output of a light-sensitive sensor, waiting for the light to be interrupted by an object. While light is present on the sensor, the I/O port bit is TTL high. When light is removed or interrupted, the sensor goes low. This is where the bit-test instructions shine. You'd simply loop reading the sensor until the condition you're waiting for is met. At this point, your program exits the read loop and continues executing other instructions in response to the sensor condition. You can simulate a similar condition with the following code:

```
MOVLW   0FFH        ;LOAD W WITH FFH
MOVWF   DATAPORT    ;TURN OFF LED
MOVLW   B'00000001' ;LOAD W WITH 01H
MOVWF   SCRATCH     ;LOAD SCRATCH WITH W
LOOP
BTFSS   SCRATCH,0   ;TEST BIT 0 IN SCRATCH
GOTO    LOOP        ;SKIP IF BIT 0 = 1
```

```
BCF             DATAPORT,7      ;TURN ON LED
GOTO            $
```

This code segment sees Bit 7 of the SCRATCH register set and exits the loop to turn on the LED. Change BTFSS to BTFSC. What occurs is that you'll never leave the loop comprised of the BTFSC and GOTO instructions.

Here's how to check the status bits in the Status Word Register:

```
;Check the CARRY
BTFSS           STATUS,C        ;IF C IS SET SKIP GOTO
INSTRUCTION
GOTO            WHERE_EVER
```

Checks the 0 bit in the STATUS register (f03) and skips the next instruction if set. BTFSS could also be BTFSC:

```
;Check the ZERO
BTFSS           STATUS,Z        ;IF Z IS SET SKIP GOTO
INSTRUCTION
GOTO            WHERE_EVER
```

I can guarantee you'll use both above examples more than once.

• ***CALL k; RETLW k.*** CALL is used to jump to a subroutine at a particular address, execute that subroutine and hopefully find a RETLW instruction that returns to the origin of the CALL + 1 instruction. This is illustrated as follows:

```
START
BSF             DATAPORT,7      ;TURN OFF LED
CALL            TURNON
GOTO START

TURNON
BCF             DATAPORT,7      ;TURN ON LED
RETLW 0                         ;RETURN WITH A 0 IN W
```

Once again, get out the logic probe or scope, as this will be moving quickly. TURNON is the subroutine that ends with RETLW 0. It's entered from CALL TURNON. Since this logic should be obvious to you know, I won't expound upon it any further.

The unique feature of the RETLW instruction is that k can be any eight-bit value. RETLW is useful in look-up tables because values can be returned to W when the subroutine ends. Here's a look:

```
CALL            SHOWAA          ;CALL THE SHOWAA SUB-
ROUTINE
GOTO            DISPLAY         ;GO SHOW THE RESULT
ON THE DISPLAYS
SHOWAA
                NOP             ;IDLE HERE ONE CYCLE
                RETLW 0AAH      ;RETURN WITH AAH IN W
```

You should see 10101010 in the displays.

Summing Up

In this article, I've tried to give you all the architecture and instruction-set information you need to get started using the PIC16C5X. Run the example code and change things around to see what happens. If you need any assistance, please feel free to give me a ring or fax at 407-454-9905, or leave a note on the E D Technical Publications BBS at 407-454-3198. ■

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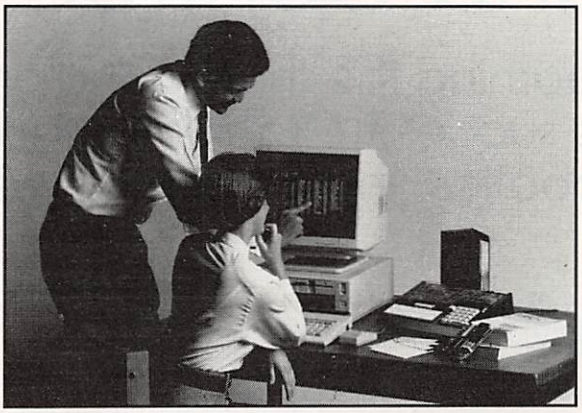

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By Steven Montgomery

Small DC-Motor Theory and Control

Learning the theory and practice of dc motors is vital to successful implementation of locomotion in amateur robotics and other motor-driven motion applications

Modern technology provides many exciting opportunities for the electronics experimenter to become involved in some pretty sophisticated and sometimes esoteric projects. To me, the most exciting area is currently mobile robotics. The ability to make a machine that can move under its own power and interact in its environment in a dynamic fashion is a truly fantastic pursuit.

In amateur robotics, it's common—in fact, almost universal—to use dc motors as the motive elements, because of their ready availability and cost and the cost and the difficulty and complexity of implementing the control circuitry of the ac-motor alternative. While it's true that ac motors have the advantages over dc motors of being easier to velocity control and being smaller in size, the voltages required to operate them aren't easily achievable and they don't produce nearly as much torque as their dc counterparts do. There are techniques, of course, such as vector control, to produce and control low-speed torque in ac motors, but to achieve this is very complicated and expensive. So, dc motors remain the overwhelming choice for low-cost robotic motion.

The method of controlling the small dc motors that are the subject of this article is a bit of a black art to most people, but it's imperative that you understand the control procedures required to effectively use them in practical projects.

The two basic types of control you *must* be able to impress upon any motor in a motion-control application are direction and speed. Direction control, obviously, makes the motor go forward or reverse, while speed control serves to change the speed of the motor based on some speed-reference input. The speed-control portion can be either open- or closed-loop. In open-loop, the control circuit doesn't monitor or regulate the motor's speed. It simply outputs a voltage proportional to a speed command. Closed-loop control uses some type of feedback to monitor the motor's speed and make corrections for load change to maintain a constant speed from no-load to full-load conditions.

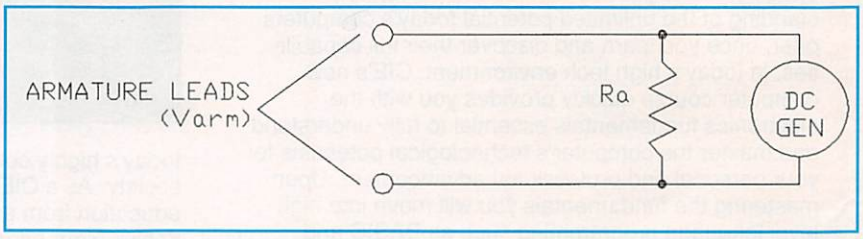


Fig. 1. Equivalent circuit for a dc motor.

In this article, I'll show you how a dc motor works and how these types of controls work. Then I'll discuss such topics as regenerative and dynamic braking, different types of velocity feedback and position sensing.

Dc Motor Operation

Dc motors come in a variety of configurations and horsepower ratings. Larger motors use field windings to generate the magnetic field required for motor action. Since the field winding carries a residual resistance, it produces unwanted heat in generating its magnetic field. This heat causes the motor to be inefficient and power-hungry. Though generation of heat with large motors is no big deal, it is a big deal with smaller motors, the kind you and I will be using. With these smaller motors, heat generation becomes a problem. So, with dc motors rated to deliver 0.1 HP or less, permanent magnets are used to produce the required magnetic field.

To understand how these motors work—and, thus, how they're controlled—you must know two fundamental relationships. One is that the current drawn by the motor is determined by torque load. The other is that the voltage applied to the armature determines speed. I'll discuss the second relationship first.

Under no-load conditions, if you place 6 volts on the armature of a 12-volt dc motor, the motor would run at 50% of its full rated no-load speed. If you were to double the voltage, the motor's speed would also double. You'd think that if a motor has an armature resistance of 2 ohms and an armature potential of 12 volts, the motor would draw 6 amperes. However, if you apply 12 volts across the same motor with no load applied to the shaft and measure the current be-

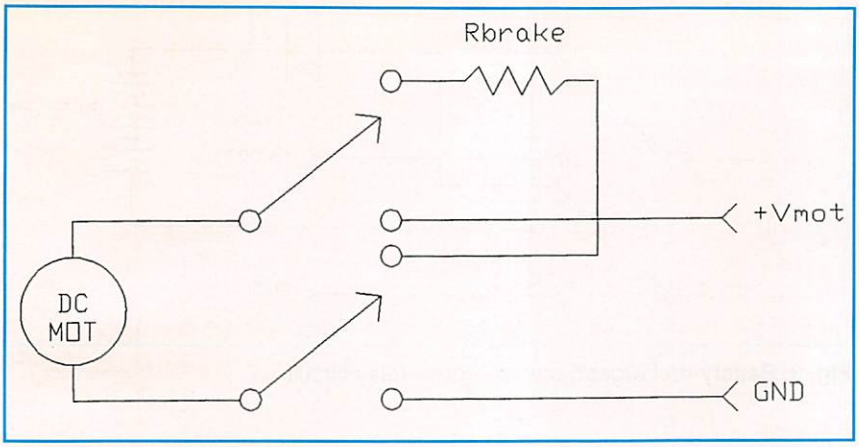


Fig. 2. A dpdt relay circuit that implements dynamic braking.

ing drawn by the motor, you'd discover that the measurement would register nowhere near the expected 6 amperes and, in fact, would be probably more like 0.1 ampere. At this point, you'd be asking yourself why this is the case.

To answer your question, lets look at the equivalent circuit for a dc motor shown in Fig. 1. From right to left, you notice a V_{arm} voltage source applied to an R_a armature resistance.

Note the equivalent voltage generator shown in parallel with the armature resistance. As an electric motor turns, it generates a voltage. This back voltage is known as back emf, the magnitude of which varies inversely with the load on the shaft. At no-load conditions, the output of this generator is at its highest value, counteracting the armature voltage. In an ideal motor, no current would be drawn at all because back emf would equal V_{arm}, and the voltage drop across the resistor would be real. However, since all motors require some torque to overcome losses in the turnings and commutators, back emf will always be slightly less than V_{arm}, causing a small voltage drop across R_a and, thus, causing the motor to draw a small amount of current.

As the load on the shaft increases, the back emf decreases. This causes a larger voltage drop across R_a, thus causing the motor to draw more current. In the worst case, enough load is placed on the shaft to cause the shaft to stop turning. Then, back emf is 0, and the entire V_{arm} is dropped across R_a, resulting in maximum current being drawn, a condition called "stall current" because it's the current drawn when stall torque is placed on the motor shaft (causing the motor shaft to stop).

It's important that you understand the foregoing because a motor's speed is directly proportional to back emf, not V_{arm}. As the torque load on the shaft increases, V_{arm} remains constant but back emf decreases as the current drawn increases. If V_{arm} is raised at this current draw, back emf would also go up by the same proportion. Therefore, if V_{arm} is increased in proportion to current drawn such that back emf is constant, a constant motor sped can be maintained.

Since, back emf is difficult to conceptualize and even more difficult to model in a control system, I presented the above discussion only to introduce the concept to you and provide a basis for a real-world model of the motor that's easily attainable.

Since you know that as torque loading increases, current draw also increases, you can calculate the difference between V_{arm} and back emf. The voltage dropped across R_a doesn't produce motion. Only the voltage over and above the R_a voltage drop is converted to speed. Thus, if a motor has a 20-ohm armature and draws 0.1 ampere of current, it will drop 2 volts across it. This means that only 10 of 12 volts will be converted to speed. If current draw increases again, so does the voltage drop, and down goes speed, which is in line with our earlier discussion of back emf.

The foregoing is important to understand because it's how the first relationship I described above relates to the second. As more torque is placed on the motor shaft, current draw goes up. As current draw increases, the voltage drop increases and speed decreases. More voltage would have to be applied across the armature at this point to maintain constant speed. For lack of a better name, this effect of increased torque causing motor speed to droop is called counter-electromotive force, or cemf, which is simply the amount of voltage converted to heat in the motor windings resulting from current draw. cemf can be calculated using the formula:

$$cemf = I_{arm} \times R_{mot} \quad \textbf{(Eq. 1)}$$

where I_{arm} is current draw due to toque load and R_{mot} is the published resistance of the motor.

The amount of current that a motor draws is determined by the torque load on the motor. This can be described using a torque constant, or K_t, which specifies torque produced per current drawn and, thus, has units of oz.-in./A (ounce-inches per ampere). This constant is determined and published by the manufacturer of the motor. K_t can be calculated if no-load torque T_{nl} and no-load current I_{nl} are known, using the equation:

$$K_t = T_{nl}/I_{nl} \quad \textbf{(Eq. 2)}$$

where T_{nl} is in oz.-in. and I_{nl} is in amperes.

Once K_t is determined, its possible to calculate cemf for any toque load. Simply calculate I_{arm} using the equation:

$$I_{arm} = T_{load}/K_t \quad \textbf{(Eq. 3)}$$

where T_{load} is torque load in oz.-in. on the motor.

Now let's work an example using these equations. Assume that you know the rated torque and current specifications (which would be published in the motor data book). Eq. 2 uses no-load toque and current specifications, but the rated ones work just as well. You know that a particular dc motor will provide a 3.5-oz.-in. torque at 1.8 amperes. Using Eq. 2 to solve for K_t:

$K_t = T_{rated}/I_{rated}$
$K_t = 3.5$ oz.-in./1.8 ampere
$K_t = 2.7$ oz.-in./A

Suppose we have an application in which this motor will have a torque load of 2.7 oz.-in. (to make the numbers work out easily). Use Eq. 3 to solve for I_{arm}:

$I_{arm} = T_{load}/K_t$
I_{arm} = 2.7 oz.-in./2.7 (oz.-in./A) I_{arm}
= 1 ampere

Now, knowing that the motor's resistance is 2.6 ohms (also published in the motor data book), calculate cemf using Eq. 1:

$cemf = I_{arm} \times R_{mot}$
cemf = 1 ampere x 2.6 ohms
cemf =2.6 ampere-ohm = 2.6 volts

This means that if the motor is rated at 12 volts and that is what's being applied to the armature, only 9.4 volts of this potential would be translated into speed. You can calculate exactly how much the voltage drop will effect the speed and what the speed will be at any torque load using other constants. More on this later.

Stall torque is the torque at which the motor shaft stops rotating. The reason the motor shaft stops rotating is that current draw is so high that it causes a voltage drop in the armature winding equal to the rated motor voltage. This voltage drop is cemf. Therefore, stall torque is the torque at which cemf equals the voltage applied to the armature. To derive the equation for stall torque, use the following procedure:

(1) First, cemf must equal the applied armature voltage. Since you know cemf and the resistance of the motor, you can use Ohm's law to calculate how much current is being drawn by the motor at the stall torque, using the equation:

$I_{stall} = cemf(V_{arm})/R_{mot}$ **(Eq. 4)**

(2) Now calculate how much torque is produced at this current by rearranging Eq. 3 so that:

$T_{stall} = I_{stall} \times K_t$

(3) Not all of this torque is available at the shaft to produce motion. There's a certain amount of torque (the no-load torque) that's used up in friction losses within the motor.

$T_{stall} = [(I_{stall} \times K_t) - T_{nl}]$ **(Eq. 5)**

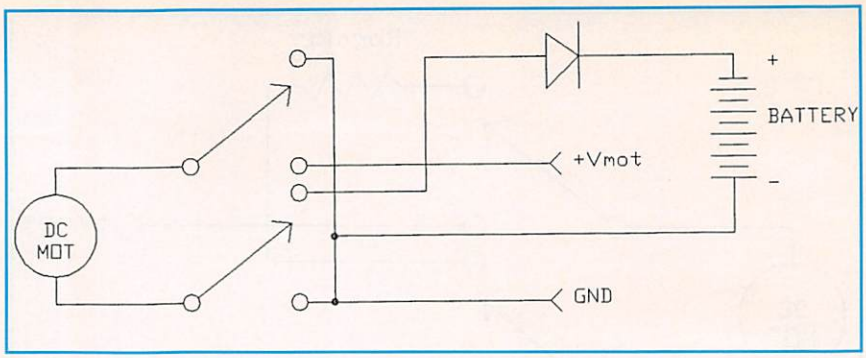


Fig. 3. Battery-recharger/motor-energizer relay circuit.

Using Eq. 5, you can work an example using the motor data from the previous example. For a 12-volt motor, cemf at stall torque would be 12 volts. Use Eq. 4 to solve for stall current:

$I_{stall} = cemf/R_{mot}$
I_{stall} = 12 volts/2.6 ohms
I_{stall} = 4.6 ampere

No-load torque is assumed to be 0.95 oz.-in. This and the value just calculated for I_{stall} can be plugged into Eq. 5 to determine T_{stall}:

$T_{stall} = [(I_{stall} \times K_t) - T_{nl}]$ **(Eq. 6)**

T_{stall} = [(4.6 amperes x 2.7 oz.-in./A) –0.95 oz.-in.]
T_{stall} = [12.42 oz.-in.) – 0.95 oz.-in.]
T_{stall} = 11.47 oz.-in.

This stall torque value is very important in rating a motor. You mustn't use the motor in an application in which the required torque exceeds this torque, or you'll have to provide overvoltage to the armature to develop motion. This would result in excessive heating in the armature and would probably damage the motor.

I said earlier that the speed of a motor is determined by the voltage applied to its armature. Exactly how much speed is produced for any given voltage is what I'll now discuss.

Remember that it was established that only the voltage in excess of cemf is converted to speed. Therefore, if 12 volts is applied to the armature and cemf is 2 volts, only 10 volts is translated to speed. So, how do you relate the 10 volts to the actual speed produced by the motor? The answer is the voltage constant, K_e, which is determined by the motor design and winding. Its value is published in the motor data book in units of volts/krpm, which means that it produces so many krpm for every volt applied to the armature. You can use a rule-of-thumb calculation for K_e:

$K_e = K_t/1.35$ **(Eq. 7)**

Speed, then, is determined by simply dividing the armature voltage by the voltage constant, K_e. Hence, the following equation is generated:

$S_{mot}(krpm) = V_{arm}/K_e$ **(Eq. 8)**

where S_{mot} is motor speed in thousands of rpm; V_{arm} is the voltage applied to the armature; and K_e is the voltage constant for the motor. Equation 7 assumes, though, that all of the voltage applied to the armature is converted into speed. It was established above that it doesn't, due to cemf. Therefore, cemf must be subtracted from the armature voltage to establish true armature speed.

$S_{mot}(krpm) = [V_{arm} - cemf]/K_e$ **(Eq. 9)**

or

$S_{mot}(krpm) = [V_{arm} - (I_{arm} \times R_{mot})]/K_e$

We'll now work an example using Eq. 9. From Eq. 7, and using the motor data stated above, you can calculate K_e as follows:

$K_e = K_t/1.35$
K_e = 2.7(oz.-in./A)/1.35
K_e = 2 volts/1,000 rpm

Assume that the torque load on the motor is 2.7 oz.-in. Using Eq. 3, I_{arm} = 1 ampere. Applying these numbers to Eq. 9, you can solve for motor speed

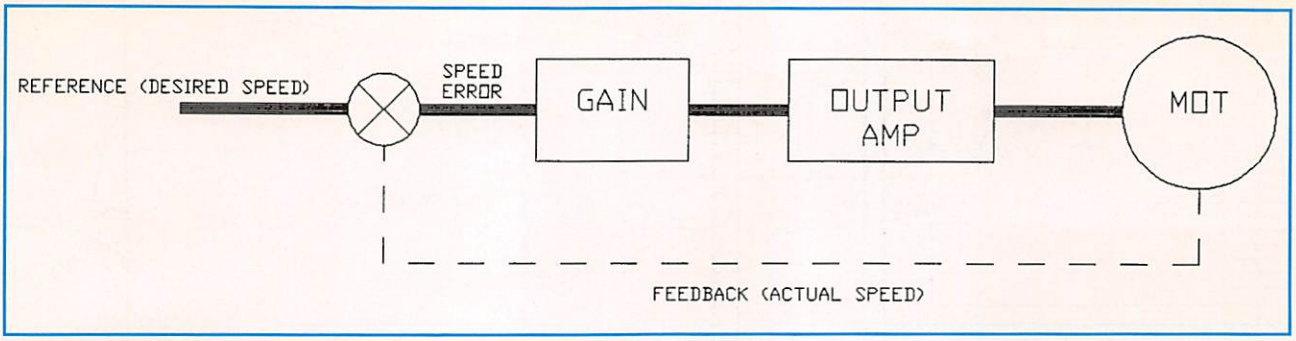


Fig. 4. A basic control system that incorporates feedback into closed control-loop design.

when torque load on the shaft is 2.7 oz.-in. and applied armature potential is 12 volts as follows:

$S_{mot} = [V_{arm} - (I_{arm} \times R_{mot})]/K_e$
$S_{mot} = [12 \text{ volts} - (1 \text{ ampere} \times 2.6 \text{ ohms})]/2$
$S_{mot} = 9.4 \text{ volts}/2$
$S_{mot} = 4{,}700 \text{ rpm}$

At this torque load, cemf is 2.6 volts. If you wished to maintain this motor at full speed when torque increased from no-load to 2.7 oz.-in., armature potential would have to be increased from 12 to 14.6 volts, causing the total voltage converted to speed to be 12 volts after cemf is taken into account.

Braking

When the dc voltage is removed from the armature of a dc motor, the motor will coast down to a stop. As this motor is turning, generator action (the reverse of motor action) is taking place. Generator action is caused when a conductor (the armature windings) cuts magnetic lines of flux (from the permanent magnets). This induces a voltage in the conductor. If there's a closed circuit, current will flow. So, if the motor is spun and the armature leads are open, you'd be able to measure an open-circuit voltage at the armature leads. It's this principle that's used for the tachometer feedback I'll discuss later. What's of interest here is how to brake the motor once the voltage is removed. To do this, you can take advantage of the generator-action principle.

The key to understanding all of this is the law of conservation of energy, which states that "energy can neither be created nor destroyed, only changed in form." The coasting down motor has kinetic energy. The only thing causing it to coast down at all is that some of this energy is dissipated in the form of heat resulting from friction in the motor's bearings. Your goal is to transform this kinetic energy, as fast as possible, into some other form of energy. By doing this, the motor will stop.

The generator-action principle tells us that the motor will be producing a voltage across the armature that's proportional to its speed. When you place a voltage across a resistance in a closed circuit, a certain amount of current is drawn and heat is dissipated, the amount of which is determined by squaring the current being drawn and multiplying it by the resistance, commonly known as I^2R losses.

Heat is a form of energy. You need to change the rotational energy of the motor into some other form of energy to stop the rotation of the motor's shaft. You can place a load resistance across the armature, which will cause current flow due to the voltage from generator action. This current flow will produce heat in the resistor, which accounts for the rapid deceleration of the motor. Thus, rotational energy is transformed into heat.

The concept of placing a resistor across the armature to brake a coasting down motor is widely known as "dynamic breaking." The easiest way to implement a dynamic brake is to use a dpdt relay, configured as shown in Fig. 2. The motor is connected such that when the relay is energized, a voltage is impressed across the motor's armature. When the relay deenergizes, the armature connects across a resistor that brakes the motor to a quick stop.

For small dc motors of a fractional horsepower, a 0.47-ohm 10-watt resistor supplies more than enough dissipation and will serve to brake the motor rather quickly.

If you're using dc motors to propel a mobile robot, you're probably using batteries. This being the case, your designs should be power-conservative to assure that you obtain the most operating time from a single charge. Therefore, it would seem senseless to just throw away that dissipated energy from dynamic braking into the environment as unused heat. Instead, it would be nicer to use that energy to recharge the batteries. You could, then, make the batteries the load instead of a resistor and use the generator action to recharge the batteries and, hence, brake the motor.

Figure 3 shows a dpdt relay configuration that will recharge the batteries when the relay deenergizes and will turn the motor when the relay is energized. In brake mode, the motor charges the batteries as when its output is 0.6 volt greater than the charge on the batteries. Once the motor's output voltage has dropped below 0.6 volt more than the battery's voltage, the diode reverse-biases and braking action ceases. This method of braking a motor by regenerating power into the power-supply system is called regenerative braking.

Before I end this discussion, it's appropriate to talk about some applications notes that are important in the application of regenerative braking. First, you must consider the inertial load on a motor. A high inertial load stores energy as it's being turned and then releases it once the rotational force (torque) is removed. This inertial load determines how much energy must be dissipated to brake the motor. The greater the load, the longer it will

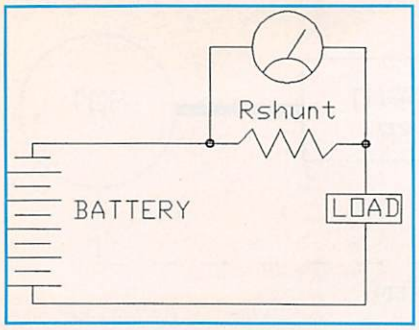


Fig. 5. Example of a basic current-feedback circuit.

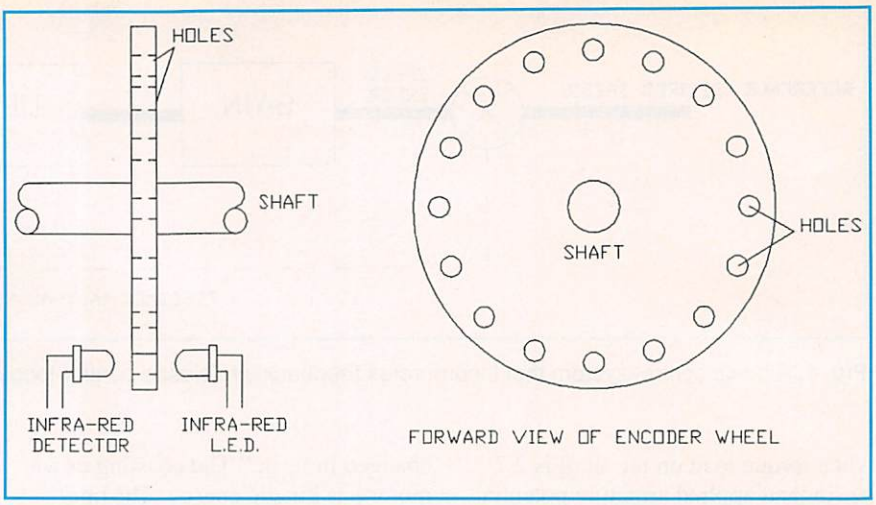


Fig. 6. A typical optical-encoder arrangement.

take the motor to coast to a stop.

If you have a relatively low inertial load, such as a robot traveling at low speed with gear-reduced dc motors, you can't realize the benefits of regenerative braking because little energy must be dissipated to brake the motor. Most of the available energy would be used up in losses in the recharging portion of the circuit rather quickly, putting little or no energy into recharging itself. But, if there's high inertial load or a large momentum, regenerative braking can perform wonderfully. In such cases, a robot is usually traveling at faster than 5 mph weighs about 75 pounds and uses directly coupled—not gearbox-reduced —dc motors.

A good portion of energy would be available through the braking process that would be used to charge the battery. I wanted to bring this up because it is important in determining the effectiveness of regenerative braking for your application. I didn't cover it in great detail here as this information is worthy of an article all by itself.

Feedback

If you're going to build a motor controller that uses a closed control loop, you must incorporate feedback into your design. A basic control system for this is depicted in Fig. 4. The desired speed is input to an error amplifier. Feedback from the motor indicates actual motor speed. The error amplifier subtracts actual speed from desired speed to attain an error signal that's literally the difference between how fast you want the motor to run and how fast it's actually running. This can be calculated as follows:

$$E_{vel} = V_{des} - V_{act} \quad \textbf{(Eq. 10)}$$

where E_{vel} is error magnitude, V_{des} is desired velocity and V_{act} is actual velocity.

This error is then amplified. The method of amplification used depends on the control scheme. If the control loop is a proportional-gain one, the amplifier will output a control signal that's proportional to the loop. For most motor-control circuits used for mobile robot drive motors, a proportional loop is sufficient. Other loops implement integral and derivative amplifiers to attain critical damping and highly accurate speed regulation, but the penalty is increased design complexity and tuning. The output of the gain amplifier is fed into an output amplifier that drives the motor. This is a basic control loop.

As I discussed earlier, knowing the current a motor is drawing is important in determining the actual speed. Remember that you could determine the armature voltage necessary to maintain a constant motor speed for varying loads if you know the current being drawn.

Current feedback is very simple to achieve. Super-accurate systems use Hall-effect devices to measure the magnetic flux around a length of wire to determine the current flowing through the wire. But these things are expensive, and there's a simpler, more-economical way to obtain current feedback.

Consider the circuit shown in Fig. 5. If the load is drawing 1 ampere of current, the drop across the resistor would be 1 volt and the meter would display 1 volt. In this case, the resistor is being used as a shunt to change the current to a readable voltage. A differential operational amplifier could be placed here to amplify the current and provide a referenced output as feedback to a closed loop.

Velocity feedback is used to tell a control loop the actual speed of a motor. The control loop subtracts this from the desired speed to arrive at an error signal that tells the gain amplifier how much to increase the output to bring actual motor speed up to desired speed and maintain it at this point.

Since a rotating dc motor's shaft becomes a generator, the output voltage of which is directly proportional to speed, a dc motor is commonly referred to as a tachometer or tachogenerator. The voltage output is linear to speed, and speed can be determined by knowing the tachometer's no-load speed and voltage ratings using the equation:

$$N_{tach} = (N_{nl}/V_{nl}) \times V_{tach}$$

where N_{tach} is the speed of the tachometer shaft; N_{nl} is the no load speed of the motor; V_{nl} is the rated voltage of motor; and V_{tach} is the actual measured tachometer voltage.

A 12-volt tachometer with a no-load speed of 10,000 rpm would produce 0.12 volt for every 100 rpm. If you fed this output voltage into an eight-bit A/D converter with a 12-volt reference, you could detect V_{tach} in 0.047-volt increments. Thus, you

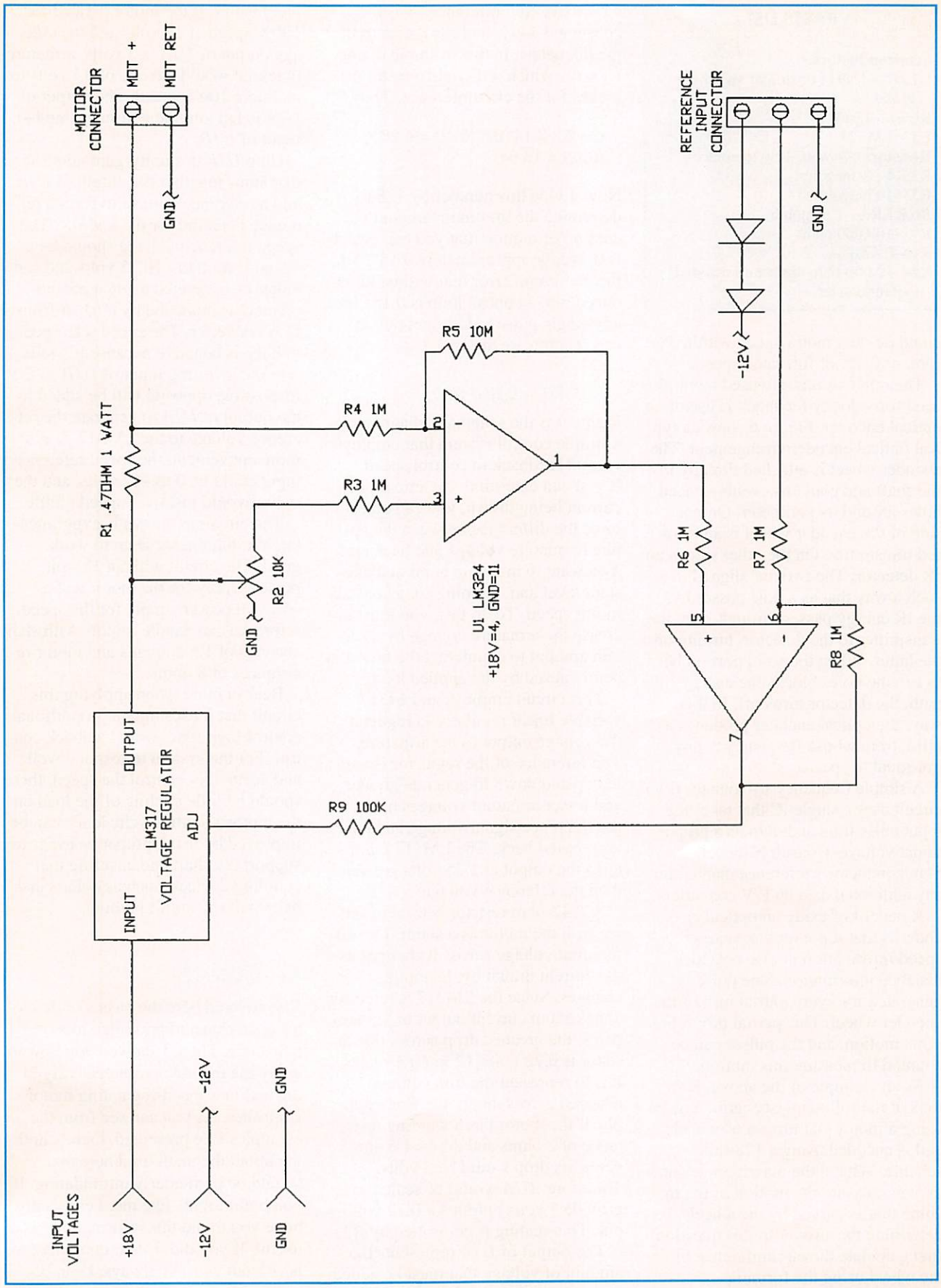


Fig. 7. This is the schematic of an experimental dc-motor speed-control circuit.

PARTS LIST

Semiconductors
D1,D2—1N914 or similar switching diode
REG1—LM317
U1—LM324
Resistors (1/4-watt, 10% tolerance)
R3,R4—1 megohm
R5—10 megohms
R6,R7,R8—1 megohm
R9—100,000 ohms
R1—0.47 ohm
R2—10,000-ohm multi-turn trimmer potentiometer

could de- tect motor speed within 38 rpm, or 0.4% of full rated speed.

The other commonly used method used for velocity feedback is use of an optical encoder. Figure 6 shows a typical optical encoder arrangement. The encoder wheel is attached directly to the shaft and contains evenly-spaced holes around its perimeter. On one side of the encoder wheel is an infrared transmitter. On the other side is an IR detector. The two are aligned in such a way that as a hole passes by, the IR energy passes through from the transmitter to the detector, turning on the latter. When the solid portion between the holes blocks the energy path, the detector turns off. In this way, the optical encoder produces a pulse train whose frequency is proportional to speed.

A simple frequency-to-voltage (F/V) circuit uses a single IC that takes the input pulse train and outputs a proportional voltage. Consult National Semiconductor's reference manual for any additional data on F/V converters.

A benefit of using an optical encoder is that it not only provides speed information, it also provides distance information. One pulse is generated for every partial turn of the encoder wheel. This partial turn represents motion, and the pulses can be counted to measure this motion.

As an example of the above, let's look at the following scenario. You're using a motor that turns a 6" wheel and is encoded using a 128-hole scheme. What's the maximum accuracy you measure the motion of the machine that is moved by the wheel? To determine the answer to this question, first calculate the circumference of the wheel using the formula:

$$c = 2\pi r$$

where c is circumference, π is the constant 3.1412, and r is radius (half the diameter). In this example diameter = 6", which will yield a result in inches for the circumference. Thus,

$$c = 2 \times 3.1412 \times (6"/2) = 4.28 \times (6"/2) = 18.84"$$

Now divide this number by 128 to determine the minimum amount (accuracy) of motion that you can detect is 0.147, or approximately 0.15". So, the maximum error that will be introduced into a control loop is 0.15" for any single pulse (additional pulses can accumulate the error).

Control Circuit

Figure 7 is the schematic diagram for a simple control system that employs current feedback to control speed. If you can determine the amount of current being drawn, you can determine the difference between the applied armature voltage and back emf. You want to maintain bemf at a constant level and, in doing so, a constant motor speed. To do this, you must increase the armature voltage by a certain amount to counteract the droop in bemf caused by the applied load.

This circuit employs an LM317 variable linear regulator to regulate the voltage output to the armature. The reference of the regulator is varied up and down to generate greater and lesser armature voltages based on the reference signal voltage and the current fed back. The LM317 maintains the output at 1.25 volts greater than the reference voltage.

A 0.47-ohm resistor is used in series with the motor as a shunt. The differential voltage across it changes as the current drawn by the motor changes. Since the LM317 is rated for a maximum current output of 1.5 amperes, the greatest drop across this resistor is 0.72 volts. Chip *U1A* scales this to represent the true voltage dropped across the motor. For example, if the motor has a winding resistance of 2 ohms and draws 1.5 amperes, its drop would be 3 volts. Therefore, *U1A* would be scaled to provide 3 volts output for 0.72 volt input. This scaling is controlled by *R2*.

The output of *U1A* represents the amount of voltage that must be added to the desired no-load speed voltage to maintain constant speed. To explain better, if the motor is rated for 100% speed at 12 volts and the voltage output of *U1A* is 3 volts, armature potential would have to be 15 volts to maintain 100% speed. The output of *U1A* is fed into the non-inverting (+) input of *U1B*.

Chip *U1B* is a unity-gain amplifier that sums together the output of *U1A* and a reference voltage to form a reference potential for the LM317. The speed reference voltage should be a signal from 0 to –10.75 volts and can either be generated using a potentiometer, as indicated by *R10*, or from a D/A converter. The speed reference voltage is negative because it's fed into the inverting input of *U1B* so that its positive opposite will be added to the output of *U1A* to generate the reference voltage to the LM317. If it's more convenient, the speed reference input could be 0 to –12 volts, and the motor would just over-speed a little.

The circuit as shown is experimental, but initial tests seem to work good. The circuit with an 18-volt power supply for the motor and a –12-volt power supply for the speed reference can handle motors with stall currents of 1.5 amperes and motor resistances of 8 ohms.

Bear in mind when applying this circuit that it uses only a proportional control loop for current feedback control. For the system to respond well and accurately control the speed, there should be little cycling of the load on the motor's shaft. Cyclic loads can be improved by using proper bearings to support the shaft and ensuring that coupling devices, such as collars and belts/pulleys, aren't binding.

In Closing

I've covered here the basics of dc motor operation and presented lots of equations. Then, I showed you how to apply the theories presented early in the text in a speed-regulating motor controller. As you can see from the examples I've presented, there's nothing about the math used here that should be particularly intimidating. If you build robots like me, I especially hope you found this information to be useful. If you did, I'd certainly like to hear from you. As always, I can be reached by writing to me at 3845 SW 25, Oklahoma City, OK 73108. ■

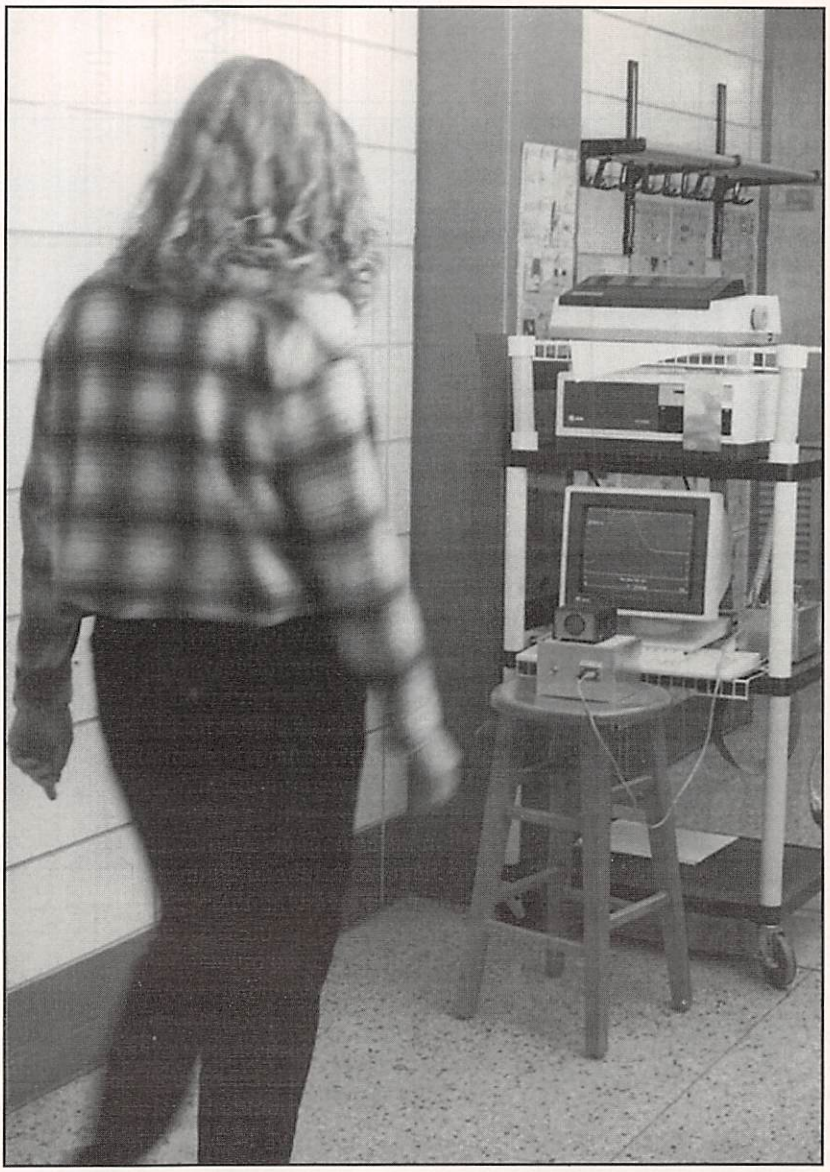
By R.C. Nicklin

Timing *QuickBASIC* for Physics-Lab Applications

Some simple projects you can build to conduct physics experiments in the lab and at home, using a PC

I develop programs and apparatus for my students to use for data acquisition in physics labs. Most of my experiments measure events that are completed in less than a second or are repetitive and require time resolution of the order of a few milliseconds. One of my most-persistent problems has been to provide a believable time calibration. Numerous schemes exist to do this are based on expensive peripheral cards or presumed instruction times for various PCs, but I prefer a direct approach. I've built a simple calibration box that derives its timing from the 60-Hz ac power-line frequency. I attach this to a PC in place of an experiment and adjust my *QuickBASIC* program until it gives the correct times. Then I *know* what the timing is.

In this article, I'll describe how to: build and use the calibration circuit; use Keithley MetraByte DAS-4 and DAS-8 data-acquisition cards to bring in switch readings; build a sturdy breakout box to connect experiments to the MetraByte cards and specialized *QuickBASIC* programs to do digital input and give the correct timing for particular experiments. Applications I'll cover include a phototransistor switch to measure the velocity of a falling body; lever switches to study a driver's reaction time; magnetic switches to determine glider velocity on an air track, power on an exercise bike and the motion of a sprinter coming out of starting blocks; and a sonic ranger to follow a subject's motion.



PCs in the Physics Lab

There can be no doubt that computers are versatile as instruments in laboratory instruction. Properly equipped and programmed, a PC becomes a timer, a voltmeter or an oscilloscope. It can calculate, tabulate, plot and print. Although some commercial apparatus and software are available for use in labs, they're mostly too expensive and too inflexible for my purposes. Since we have a considerable investment in conventional apparatus for undergraduate laboratories, I tailor some experiments and software to use it.

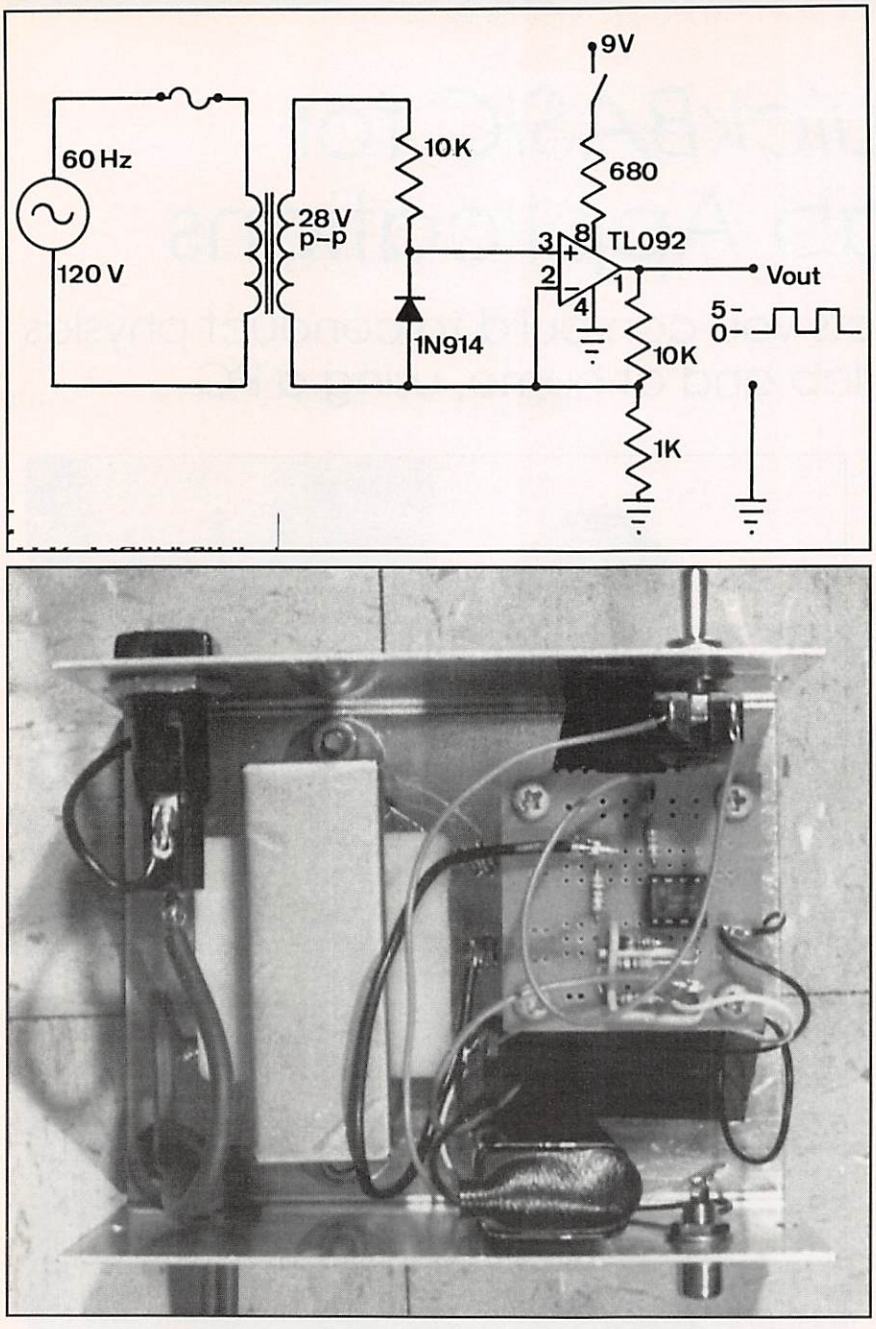


Fig. 1. 60-Hz calibrator circuit details and photo of assembled unit.

For the past four years, I've equipped each lab PC with a Keithley MetraByte DAS-4 card, a homemade interface box and applications programs written in *QuickBASIC*. Many of these programs need a time calibration, wherein lies a problem. PC/XTs and ATs use 8253 and 8254 timer chips, which have three channels. Some 386 support chips also include the 8254. Unfortunately, all three channels are used by a PC. One channel is a real-time clock that provides date and time. It "ticks" at about 18.2 times per second, and it's resolution is only ±55 ms, which isn't good enough for timing brief events.

If you can afford it, probably the best way to obtain decent timing capability is to add a counter/timer card. Also, some multi-function I/O cards have analog inputs, digital I/O and counter/timers. An assembly-language software fix is another possibility. The only commercially available software timer I've ever heard of turned out to work only with programs written in C.

There are problems with all such methods. I like to know with certainty what my instruments are measuring. Even with a fancy timer card, I'd have to feed in a signal from a stable function generator, monitored by a counter, and compare the frequency claimed by the card with the frequency fed in. I simply won't rely on a manufacturer's claims of accuracy. And unless an assembly-language timer is actually reading an independent hardware timer, there's the problem of counting machine cycles for the program's instructions and converting to obtain execution time. Again, I'd want an *independent* way to know the timing.

60-Hz Solution

I decided to feed 60-Hz square waves, derived from power line ac, to my PC in place of the experiment. For example, if 10 square-wave pulses come through, I'd know the elapsed time is 10/60 second. The portable 60-Hz calibrator shown (A) schematically and (B) in wired form in Fig. 1 uses commonly available components, most of which the average electronics experimenter already has on his workbench.

In this circuit, the transformer steps down 120 volts ac and isolates the resulting 28 volts peak-to-peak from the ac-line source. The diode half-rectifies the sine waveform and feeds it to the noninverting input of the operational amplifier, which yields a gain of about 11. Since the op-amp power supply delivers about +6 volts, the waveform is clipped, resulting in a train of square-wave pulses oscillating between 0 and 5 volts.

I assumed that power companies had to maintain the frequency to about 1 part in 10,000, a figure I vaguely remembered reading many years ago. I was curious to know what the current standard is and presumed this would be common knowledge in any electrical utility. To my surprise, it's not! Several calls to my two local power companies failed to turn up anyone who even knew what a Hertz is, much less the meaning of 60 Hz. So I called the major power company in North Carolina. Same story. Eventually, I got through to a real engineer who dealt with power transmission.

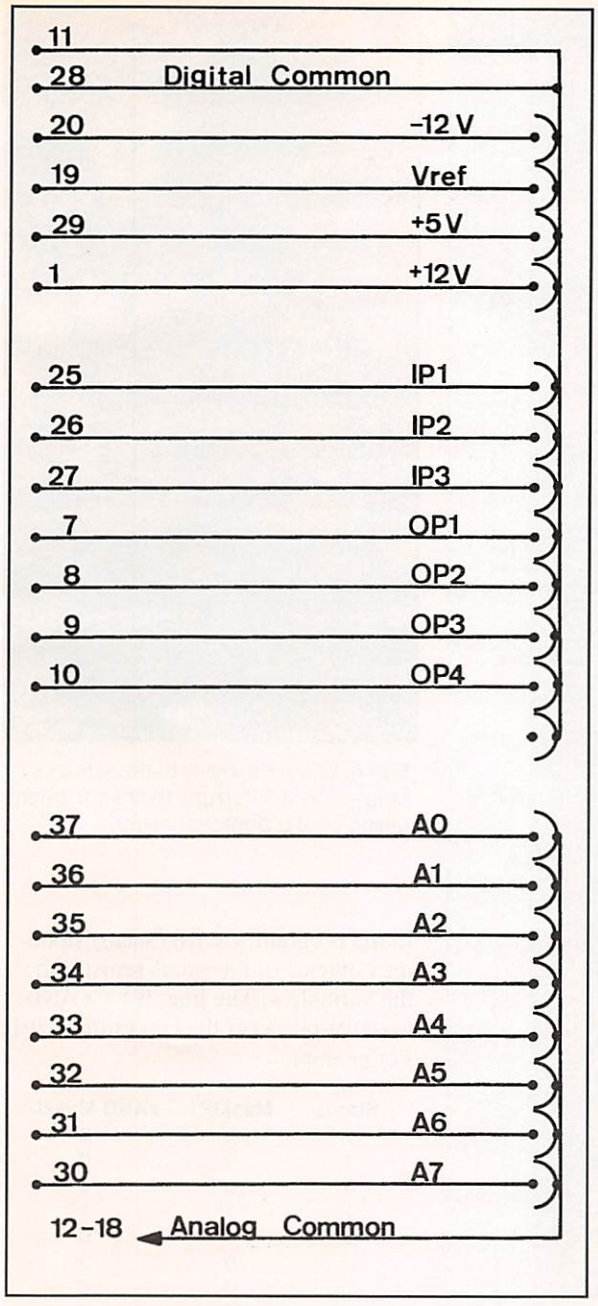


Fig. 2. Schematic details of an interface box that accepts phono cables from experiments. A ribbon cable connects the box to a DAS-4/8 card in the PC.

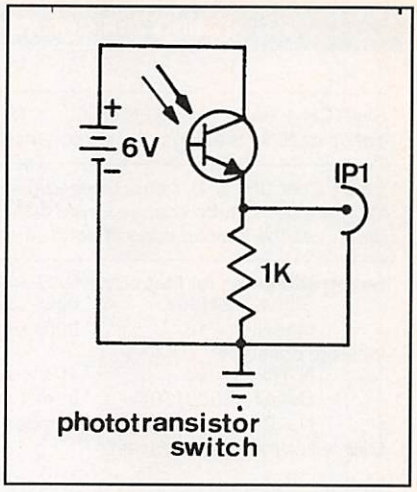


Fig. 3. In this phototransistor switch circuit, light causes IP1 to register about +5 volts. IP1 drops to 0 Volts when beam in interrupted.

Listing 1. Reading 10 Interruptions of a Light Beam Falling on a Phototransistor Switch

```
'_____________________________________________
' SWITCH-0.BAS     RC Nicklin          12 Nov 1993
' How to read a switch with QuickBASIC and DAS-4 card.
'_____________________________________________
' Card was installed with base address H300.
' Status Register is at H302 (Base + 2) and contains:
'bit   7     6     5     4     3     2     1     0
'      x     IP3   IP2   IP1   x     x     x     x
' (bits 4, 5, 6 have contents of 3 input lines).
'_____________________________________________
' Values for MetraByte DAS-4/8 cards.
        Status = &H302          ' Base address + 2
        MaskIP1 = 16            ' 0001 0000

CheckInput:
        CLS 0: LOCATE 5, 1: PRINT "IP1 = "
        DO
        x = INP(Status)
        IP1 = x AND MaskIP1
        LOCATE 5, 7: PRINT "          "
        LOCATE 5, 7: PRINT IP1
        LOOP UNTIL INKEY$ <> ""
END
```

He was kind enough to send me a stripchart record of typical frequency fluctuations in daily operations that shows that the 60 Hz is maintained to ±0.01 Hz (1 part in 6,000) for several hours, with a 10-minute excursion 0.02 Hz away from the ideal. Based on this sample, it seems that a time calibration done with the 60-Hz calibrator is good to at least 1 part in 3,000, which is good enough for my purposes.

Data Acquisition

MetraByte cards evidently represent some sort of industry standard, since they're cloned by Computer Boards, Inc. and CyberResearch, Inc. Keithley recently introduced its DAS-800 series to replace the DAS-8 series and dropped prices to $350 to $450. The DAS-4 currently costs $250 and features digital input lines IP1 through IP3; digital output lines OP1 through OP4; eight-bit channels A0 through A7 for analog-to-digital (A/D) conversion in the ±5-volt range. The DAS-8/800 series cards have the same digital I/O lines and a 12-bit A/D converter.

Applications in this article require finding the time to close or open a switch. In turn, this requires reading digital input lines and knowing the time (ΔT) between readings. The DAS-4/8/800 cards represent overkill for this and a less-expensive digital-only card would suffice.

The DAS-4 and DAS-8 cards come with a 37-pin male connector. Rather expensive $125 screw-type terminal boards are available for these and similar cards from other manufacturers. Since I'm constantly connecting and disconnecting various experiments to and from my PCs, I need a quick way to do this. A homemade interface box like that shown sche-

Listing 2. Program for Reading a Switch

```
'-------------------------------------------------
' SWITCH-1.BAS        RC Nicklin       12 Nov 1993
' Takes multiple readings of a phototransistor switch.
'-------------------------------------------------
' Beam clear (IP1 = 1); beam blocked (IP1 = 0).
' Program detects the change - from clear to blocked
' beam - as the leading edge of each stripe hits beam.
'-------------------------------------------------
' Set up addresses for MetraByte DAS-4/8 cards.
        Status = &H302          ' base address + 2
        MaskIP1 = 16            ' 0001 0000
' Initialize constants
        NWaves = 10             ' 10 stripes
        DeltaT = .0001764       ' from TIME-1 calibration
        N = 0                   ' number of IP1 readings.
  DIM N(NWaves), T(NWaves)

  CLS 0
  PRINT "Drop plate through light beam."
  PRINT "Times print after last interruption."
  PRINT

' Read IP1   (open = 16, blocked = 0)
' Tape stripe falls toward beam. Beam is open.
          ' Await first beam blockage.
          N = 0
          DO
          x = INP(Status) AND MaskIP1
          LOOP UNTIL x = 0

          FOR i = 1 TO NWaves
          ' Beam is blocked - await clear.
          DO
          x = INP(Status) AND MaskIP1
          N = N + 1
          LOOP UNTIL x = 16
' Beam is clear - await blockage.
          DO
          x = INP(Status) AND MaskIP1
          N = N + 1
          LOOP UNTIL x = 0
          N(i) = N
          NEXT

' N(i)*DeltaT gives the time since 1st blockage.
          FOR i = 0 TO NWaves
          T(i) = N(i) * DeltaT
          PRINT "T"; i; " = "; : PRINT USING "##.#### "; T(i)
          NEXT
END
```

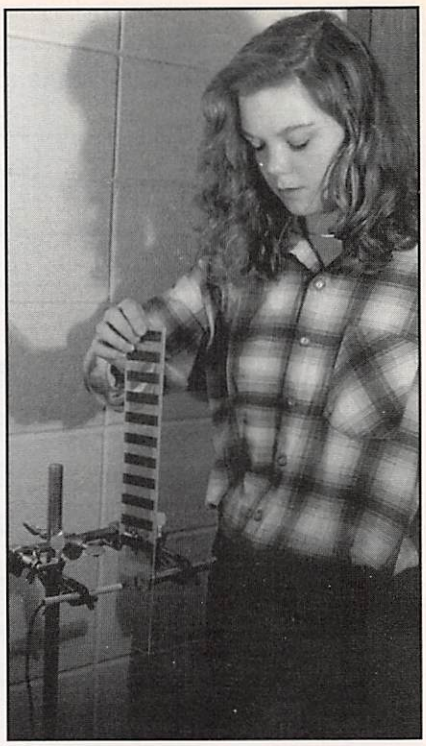


Fig. 4. When Plexiglas plate is dropped, stripes on it interrupt flashlight beam falling on the phototransistor.

matically in Fig. 2, also has a 37-pin male connector, and a ribbon cable connects it to the DAS-4.

This interface box has phono jacks for digital inputs IP1 through IP3, digital outputs OP1 through OP4 and –12, 5.0 (reference), +5 and +12 volts. All 12 lines are returned to digital ground. There are also eight jacks for analog inputs A0 through A7, which are returned to analog ground on the DAS-4. In this article, mainly IP1 is used .

The SWITCH-0 program in Listing 1 shows how to read input port IP1 on the MetraByte cards. These cards have a DIP switch for selecting a base address in the PC, usually 300h (decimal 768). At 302h (base address + 2) is a status register that lets a program communicate with input ports IP1 through IP3.

Status Register on DAS-4 & DAS-8

Bit Position	Meaning	MaskIP1
7	x	0
6	IP3	0
5	IP2	0
4	IP1	1
3	x	0
2	x	0
1	x	0
0	x	0

In the program, x = INP(Status) stores the contents of the status register in the variable x. The line IP1 = x AND MaskIP1 picks off the condition of IP1. For example:

Status	MaskIP1	xAND MaskIP1
1	0	0
1	0	0
0	0	0
1	1	1
0	0	0
0	0	0
1	0	0
1	0	0

Binary 0001 0000 = decimal 16. So when *QB* says IP1 = 16, you know that the switch is open (since its bit = 1). Conversely, when IP1 = 0, the switch is closed.

The DO...LOOP in Listing 1 keeps reading the switch and printing its condition (IP1 = 0 or 16) at the same screen position until any key is pressed.

The SWITCH-1 program given in Listing 2 shows how to read a phototransistor switch. The circuit is shown in Fig. 3. When light falls on the phototransistor, it conducts a current that causes a voltage drop across the

1,000-ohm resistor, and the top of the resistor (connected to IP1) is at about +5 volts. If the light beam is blocked, the current drops and the voltage across the resistor drops to near 0.

Figure 4 shows apparatus to measure the velocity and acceleration of a moving body. A flashlight beam falls on the phototransistor. A clear plastic plate with equally-spaced opaque horizontal stripes is held above the beam and dropped. While the beam is clear, the first DO...LOOP keeps checking until IP1 goes low (x = 0). This means the leading edge of the first black stripe has blocked the beam and timing should begin.

The FOR...NEXT loop counts the stripes, 1 to 10 (NWaves = 10). The first inner DO...LOOP repeatedly reads IP1 until the beam is clear (first stripe has passed) and increments counter N after each reading. The second inner DO...LOOP reads IP1 until the beam is blocked (next stripe has arrived) and also increments N. Count N is stored in the array N(i).

The final FOR...NEXT loop multiplies the 10 N(i) counts by ΔT (0.0001764 second), the time interval per reading obtained from a time calibration, to get time in seconds. If the time the plate takes to fall from one stripe to the next is divided into the distance between stripes, you get velocity. A typical plot of these velocities versus time is shown in Fig. 5. The slope of the straight line gives the falling plate's acceleration.

If the total time to run the FOR i = 1 TO NWaves...NEXT loop is known, and if N = total number of readings, ΔT = (total time)/N. The calibration program to measure this total time must include *exactly* the same lines as the actual data-acquisition program. Different statements require different execution times, and even seemingly minor differences in program code will give an erroneous ΔT.

How well you can know ΔT is the main problem. Two ways to find total execution time needed by the FOR i = 1 TO NWaves...NEXT loop are: (1) Use the *QuickBASIC* TIMER function and (2) use the 60-Hz calibrator. Both methods rely on taking an average. For example, suppose you measured the total thickness of a stack of 500 sheets of paper to be 50 mm. Assuming the sheets to be nearly identical in thickness, the thickness of a single

PARTS LISTS

60-Hz Calibrator (Fig. 1)
TL092 or equivalent operational amplifier
1N914 diode
Resistors—10,000 ohms and 680 ohms, both 1/4-watt, 10% tolerance transformer—120-volt primary, 18-volt secondary (Radio Shack Cat. No. 273-1515A or similar)
Dpdt power switch
1 1/2-ampere fuse and fuse holder
9-volt battery and snap connector
Eight-pin DIP socket
Chassis-mount phono jack
Ac conductor line cord
Circuit board—half of Radio Shack Cat. No. 276-159 IC board
5" x 4" x 3" project box
Standoffs and machine screws for mounting circuit board, hookup wire, solder, etc.

Interface Box (Fig. 2)
1 quad phono jack board (Radio Shack Cat. No. 274-322A)
2 octal phono jack boards (Radio Shack Cat. No. 274-370)
R8711-5ND 37-contact cable with double-ended female connectors (Digi-Key)
137M-ND 37-pin male D-shell connector (Digi-Key)
6" x 5" x 4" project box

Phototransistor Switch (Fig. 3)
Resistor—1,000-ohm, 1/2-watt, 10% tolerance resistor
Phototransistor (Mouser No. 551-PH104 and BIC pen shell
Dpdt power switch
Chassis-mount phono jack
AA cells or 9-volt battery
6-ft. audio cable with phono plug at one end stripped conductors at opposite end
Project box, 3" x 2" x 1 1/2"
Penlight

Lever Switch (Fig. 8)
Snap-switch (Mouser No. 101-1003 or similar) 6-ft. audio cable with phono plug at one end and stripped conductors at opposite end

Traffic Light (Fig. 9)
2N2222 transistors (2)
Red and green light-emitting diodes
Resistors—470 ohms (2) and 2,200 ohms (2), all 1/4-watt, 10% tolerance
Normally-open pushbutton switch
Dpdt power switch
9-volt battery and snap connector
6-ft. two-conductor cable
6-ft. audio cable with phono plug at one end and stripped conductors at opposite end
2 1/2" x 3" perforated board
3" x 2" x 1 1/2" project box
Standoffs, machine screws, hookup wire, solder, etc.

Magnetic Switch (Fig. 11)
130-volt, 50-mA magnetic switch (Mouser No. 507-AMS-20I or similar). At least eight of these can be wired in parallel to one 6-ft audio cable equipped with a phono plug at one end and stripped conductors at the other end.

Note: The programs described in this article and their *QuickBASIC* versions for these applications are available on a floppy diskette (QuickBASIC isn't required) is available for $10 from RC Nicklin, Department of Physics and Astronomy, Appalachian State University, Boone, NC 28608.

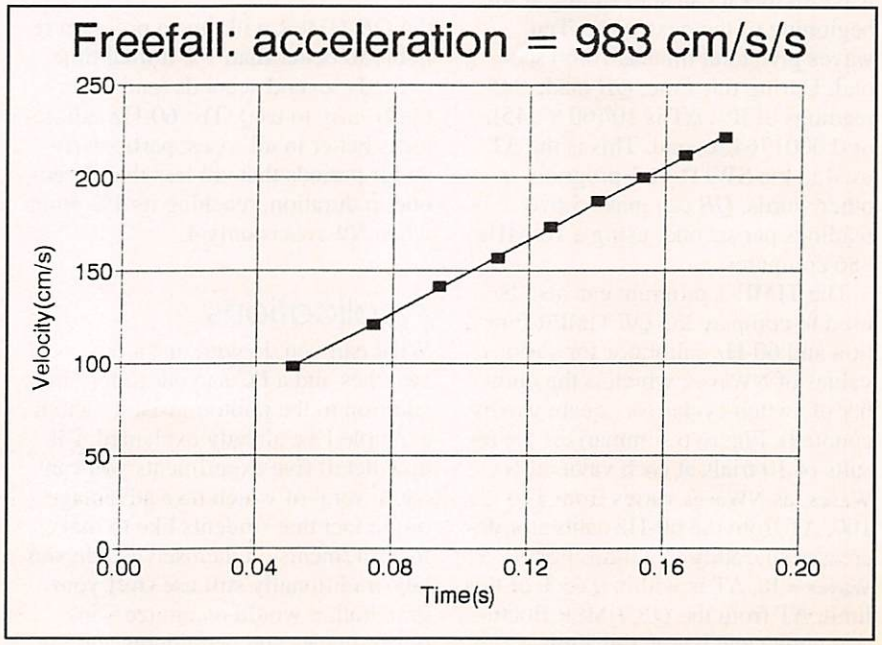


Fig. 5. This graph plots velocity-versus-time for falling Plexiglas plate.

sheet is 0.10 mm, found with an ordinary ruler. To apply this to timing a program, in particular, to find how long *QB* needs to read a switch, count many readings and divide the count into the total time.

The *QB* TIMER function returns the number of seconds that have elapsed since midnight. In the program TIME-1 in Listing 3, I've put the statement Start = TIMER just before the FOR i = 1 TO NWaves...NEXT loop and the statement Finish = TIMER just after it. Then the FOR...NEXT loop took (Finish - Start) seconds. Division by the total number of IP1 readings produces ΔT1, which is a first approximation of ΔT. This method is easy, but its resolution could be better. The longer the total time the better, and if NWaves (number of beam interruptions or on/off switch cycles) were 100 instead of 10, this would be a pretty good technique. Unfortunately, the actual experiment uses NWaves = 10 because there are 10 black stripes on the plastic plate and Listing 2 is specifically tied to the 10. This is always the case—the data-acquisition and the calibration codes must agree. With its ±1-second resolution, the TIMER function, gives erratic values when NWaves is small.

The Listing 3 program calibrates time for data-acquisition program in Listing 2. The FOR i = 1 TO NWaves... NEXT loop is identical in both programs. This TIME-1 program discards the first (partial) 60-Hz square wave so that it can start timing at the beginning of the next wave. Ten waves give total time as 10/60 second. During this time, *QB* made 945 readings of IP1. ΔT is 10/(60 X 945), or 0.0001764 second. This is the ΔT used in the SWITCH-1 program. In other words, *QB* can make 5,670 readings per second, using a 16-MHz 386 computer.

The TIME-1 program can also be used to compare the *QB* TIMER function and 60-Hz calibrator for various values of NWaves, which is the number of switch cycles (or square waves counted). Figure 6 summarizes the results of 10 trials at each value of NWaves, as NWaves varies from 1 to 100. ΔT from the 60-Hz calibrator decreases smoothly to a limit. For NWaves = 10, ΔT is within 0.45% of this limit. ΔT from the *QB* TIMER fluctuates above and below this limit.

I conclude from the foregoing that the *QB* TIMER will time a program reliably to better than 1% if total time exceeds several seconds (and is certainly easy to use). The 60-Hz calibrator is better in all cases, particularly so for periods that are less than 1 second in duration, reaching its 1% point when NWaves is only 4.

Listing 3. Two Ways to Measure the T Time Needed to Read PT Switch

```
'-------------------------------------------------------
' TIME-1.BAS   RC Nicklin          12 Nov 1993
'-------------------------------------------------------
' This compares two ways to determine the time DeltaT needed
' by QuickBASIC to read a switch:
'   1) Divide the time difference in two QuickBASIC TIMER
'   readings by total number of switch readings (TotalCount).
'   2) Use 60 Hz Calibrator to establish period of 1/60 sec
'   per square wave, then divide NWave periods by TotalCount.

' Calibration program must use EXACTLY the same QuickBASIC
' statements as the data acquisition program (SWITCH-1.BAS).
' SWITCH-1.BAS monitors light intensity on a phototransistor
' as 10 tape stripes on a transparent Plexiglas plate
' (4x44 cm) interrupt a light beam.

' To get timing right, throw away the first square wave
' reading because it enters that cycle at random, whereas
' in the actual experiment the Plexiglas strip is held
' with a clear part in the beam and the first light
' blockage is always the first tape stripe.  That is never
' known with the square wave generator.
'-------------------------------------------------------
' Set up addresses for MetraByte DAS-4/8 cards.
        Status = &H302          ' Base address + 2
        MaskIP1 = &H10          ' 0001 0000  (decimal 16)

' Initialize constants
        F = 60!                 ' calibration frequency
        NWaves = 10             ' NWaves*(1/60) = elapsed time
        N = 0                   ' number of IP1 readings

          DIM N(NWaves)

          CLS 0
          PRINT "Connect 60 Hz Calibrator to IP1."
          PRINT "Press SPACEBAR to calibrate."
          DO: LOOP UNTIL INKEY$ <> ""
```

Applications

What can you do with just a few switches and a PC as your timer? In addition to the phototransistor switch example I've already explained, I'll now detail five experiments you can try, several of which take advantage of the fact that students like to make measurements on themselves. Physics labs traditionally still use stuff your grandfather would recognize—inclined planes and pendulums and the like. I justify the added complication of computers on the grounds that, since most students don't know what they're doing anyway, they might as well do it with better equipment.

• **Driver Reaction-Time Apparatus** (Fig. 7). A program uses IP1 and IP2 to monitor the normally-open contacts on lever switches (Fig. 8) located under the brake and gas pedals. IP3 connects to a simulated traffic light, as shown in Fig. 9. In this circuit, when *S1* is closed, the green LED lights and the trigger bit connected to IP3 is +2.5 volts. Closing pushbutton switch *S2* turns on the red LED and grounds the trigger bit.

In this simulation, the driver approaches a green light with the gas pedal down. Thus, IP2 is low. Out of the driver's line of vision, someone presses *S2* and changes the light to red. This sends low *IP3* and the PC starts timing. The driver's total reac-

```
' Read Digital Input 1   (IP1:   open = 16, closed = 0)
' Await 2nd low (0 volts) on 60 Hz Calibrator square wave.
            DO
            x = INP(Status) AND MaskIP1
            LOOP UNTIL x = 0
' Beam is blocked - await clear.
            DO
            x = INP(Status) AND MaskIP1
            LOOP UNTIL x = 16
' Beam is clear - await blockage.
            DO
            x = INP(Status) AND MaskIP1
            LOOP UNTIL x = 0

' Read 60 Hz square waves at IP1.
            Start = TIMER

            FOR i = 1 TO NWaves
' Beam is blocked - await clear.
            DO
            x = INP(Status) AND MaskIP1
            N = N + 1
            LOOP UNTIL x = 16
' Beam is clear - await blockage.
            DO
            x = INP(Status) AND MaskIP1
            N = N + 1
            LOOP UNTIL x = 0
            N(i) = N
            NEXT

            Finish = TIMER: TotalCount = N

            DeltaT = NWaves / (F * TotalCount)
            DeltaT1 = (Finish - Start) / TotalCount

        PRINT "by 60 Hz        DeltaT = "; DeltaT; " s"
        PRINT "by TIMER        DeltaT = "; DeltaT1; " s"
END
```

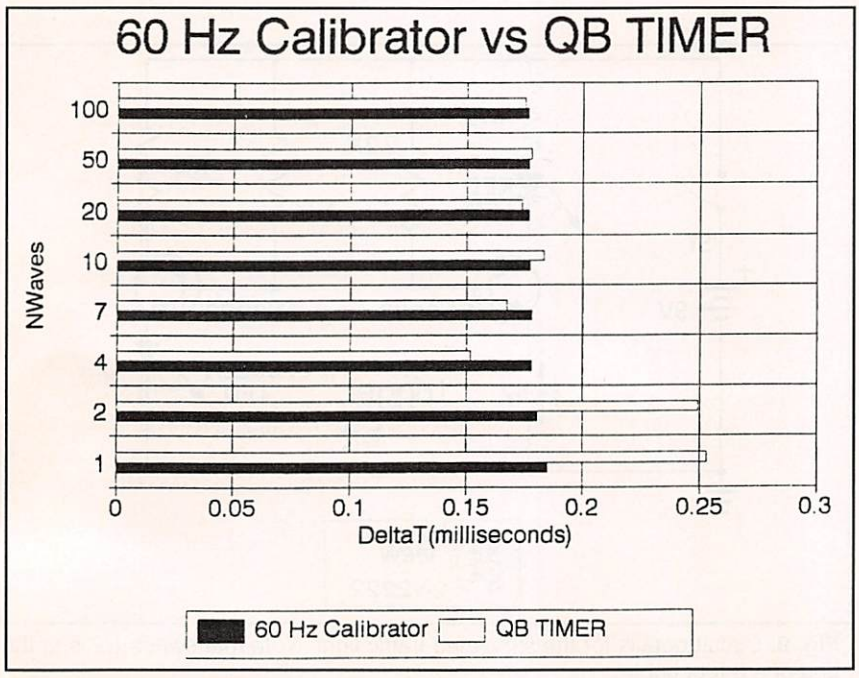


Fig. 6. The ΔT measured with 60-Hz calibrator quickly settles down to a constant value after reading as few as four square waves, whereas the *QB* TIMER function fluctuates even for 100 square waves.

tion time consists of the time he takes to release the gas pedal (IP2 goes high) plus the time it takes him to hit the brake (IP1 goes low). Total time typically ranges between 0.35 and 0.75 second.

• **Air-Track Glider Velocity Apparatus** (Fig. 10). A glider rides on a cushion of air, moving horizontally with almost no friction to oppose it. The air track is equipped with a sequence of four magnetic switches (Fig. 11) connected in parallel. Magnetic switches are very reliable. I've detected no switch bounce, even at rates of 150,000 readings per second.

The glider carries two magnets that are positioned 12.6 cm apart. As the glider moves, the two magnets open and close each switch. The PC times the switch closings and divides the time difference into 12.6 cm to give glider velocity at each switch. This apparatus makes it possible for students to do quantitative experiments on velocity, acceleration, momentum, frictional drag and conservation of energy.

• **Racer Velocity Apparatus** (Fig. 12). This setup provides a means for measuring a sprinter's velocity as she comes out of the starting blocks. A 50-meter tape is attached to the racer's back near her center of gravity. Behind each footrest block is a lever switch. When the racer leaves the blocks, the PC detects an open switch and begins timing. The tape is on a reel that carries two magnets (inset). As the tape spools off, the magnets open and close a switch and the PC collects times at about 0.25-meter intervals. Dividing this interval by the time between switch closings gives the runner's velocity (Fig. 13). Hesitation as the runner moves from one foot to the other during the first 15 meters is evident.

• **Cycle Ergometer Apparatus** (Fig. 14). When the pedals are turned on the Monark exercise bike, the large flywheel rubs against a friction belt. The pendulum mechanism (arrow) keeps a constant force on the belt, regardless of how fast or slow the rider

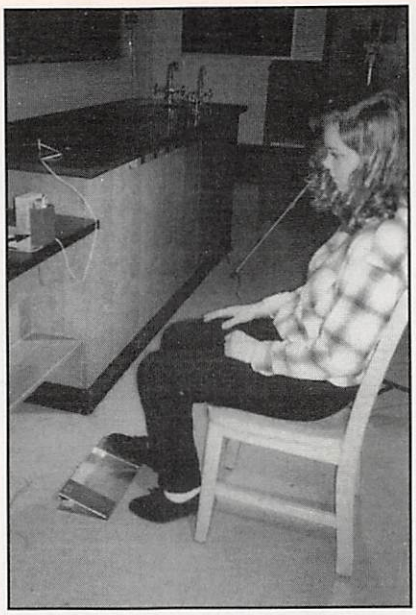


Fig. 7. Lever switches under simulated gas and brake pedals let PC measure a driver's reaction time to changing traffic light (arrow).

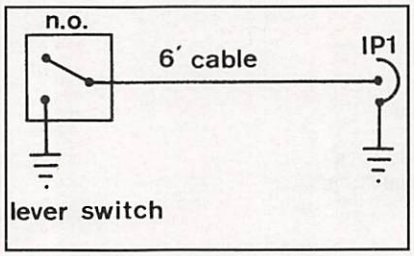


Fig. 8. Circuit details for connecting IP1 to normally-open terminal of a lever switch.

pedals. Each half-turn of the pedal crank rubs the flywheel against 3.0 meters of belt. For example, if the force is 50 Newtons (about 11 pounds), the work done is:

Force X Distance = 50 Newtons X 3.0 meters = 150 Joules

If it takes 0.20 second to do this work, the average power during that pedal cycle is

Power = Work/Time = 150 Joules/0.20 s = 750 Watts

Two magnets are on the sprocket of this Monark exercycle, and a magnetic switch is on the frame (inset). As the sprocket is turned, the magnets open and close the switch twice per revolution, exactly as in the sprint-velocity apparatus above. As usual, the PC records the switch times.

When I got involved with this exercycle instrumentation several years ago, the Human Performance Laboratory on campus was testing athletes with it. The instructions to the rider were to "Pedal as hard as you possibly can until we tell you to stop." A test supervisor looked at a stopwatch and counted pedal-crank revolutions in each 5-second interval, to a total of 70 seconds. An incredibly strenuous exercise, even for a good athlete, hardly anyone would take it a second time.

By using the PC for timing, we can

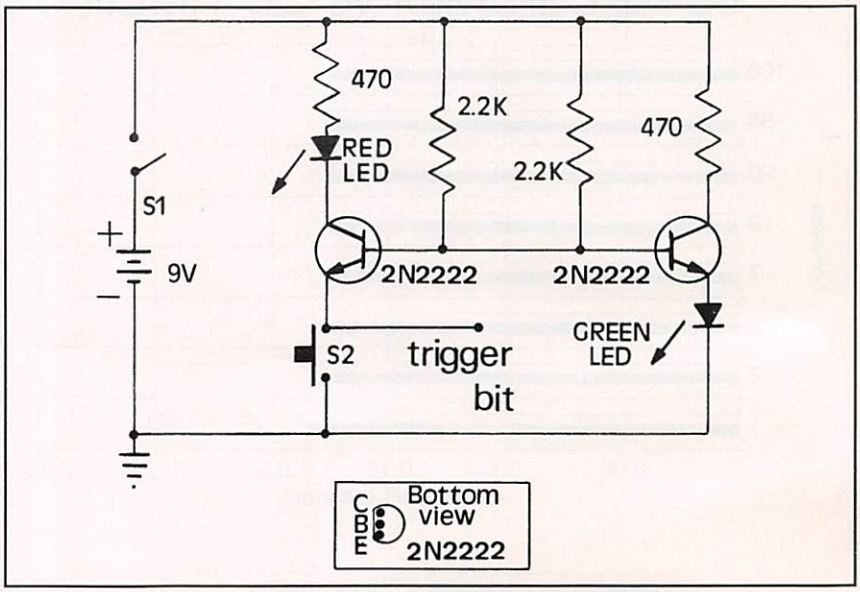


Fig. 9. Circuit details for the simulated traffic light. Note that switch *S2* is at the end of a 6-foot cable.

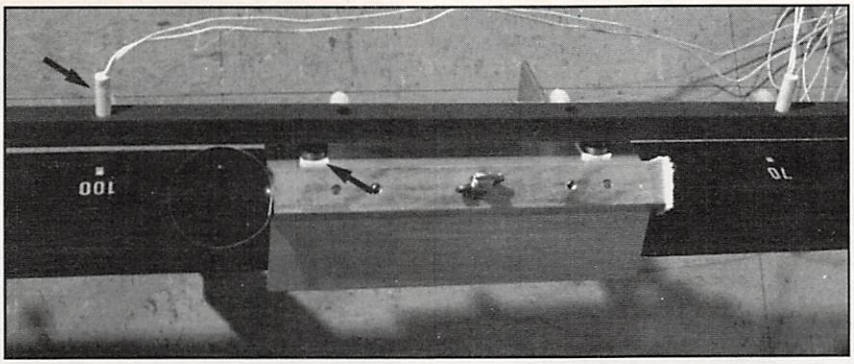


Fig 10. In this air-track-and-glider arrangement, the glider carries a magnet past magnetic switches fixed to a rail. Arrows point to the magnets.

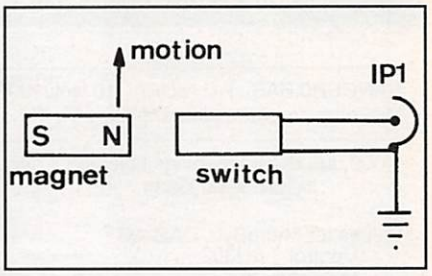


Fig. 11. In this circuit, the magnetic switch closes as the magnet nears the switch and then opens as the magnet passes out of range of the switch.

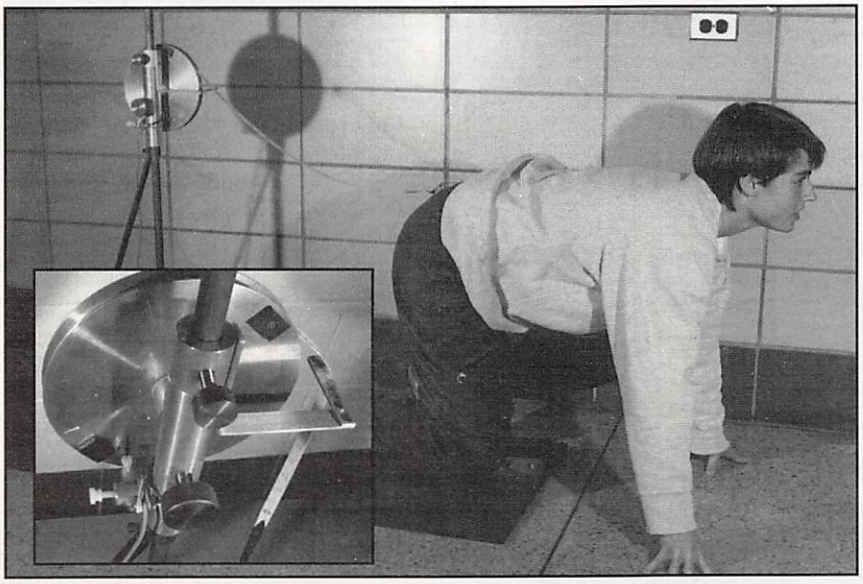


Fig. 12. Sprint-velocity apparatus uses lever switches under starting blocks so that a PC can detect when the runner leaves the starting blocks. A reel of measuring tape is connected to the runner's belt and rotates two magnets on reel past a magnetic switch (inset).

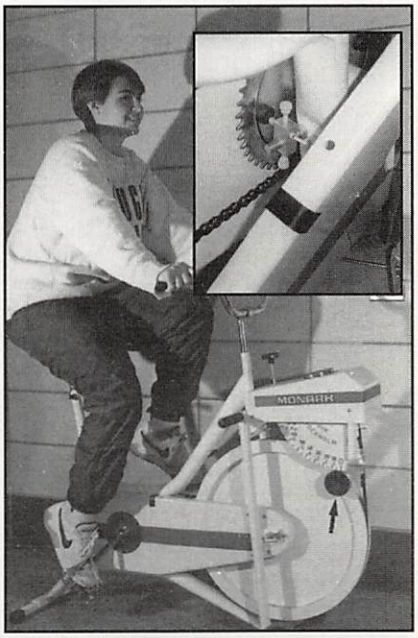


Fig. 14. Monark exercise cycle. Arrow points to pendulum on this Monark exercise cycle, which keeps a constant force on a friction belt regardless of how fast the rider pedals, making it possible to measure anaerobic work done and power output accurately in only 15 seconds. Bike sprocket carries two magnets past magnetic switch (inset).

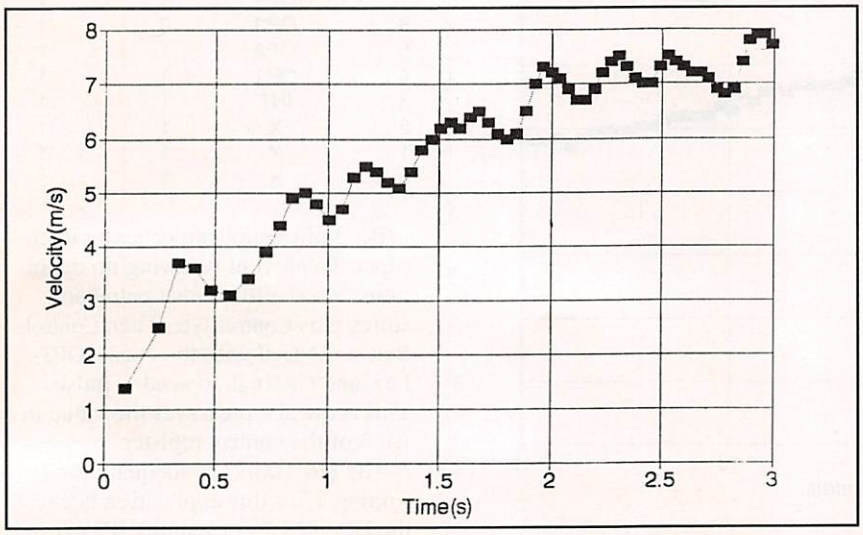


Fig. 13. This graph plots the fluctuations as a runner shifts weight from one foot to the other in velocity-versus-time format.

do a better test in 15 seconds or less. With the simple instrumentation illustrated in Fig. 15 (and a difficult program) it's possible to determine the rider's peak power, average power, time to peak and rate of exhaustion.

• **Ultrasonic Ranger Apparatus** (Fig. 16). This experiment uses sound pulses to measure a student's distance from the computer. The PC is programmed to give a real-time graph of distance versus time as the student

Listing 4. RANGER0 Program Plots Distance Vs. Time

```
'_____________________________________________
' RANGER0.BAS   RC Nicklin   10 Nov 1993  AT&T 6300 version
' Minimum program, plots Distance Vs Time.
'_____________________________________________
' 1,000,000 ECHO readings take 368.4 seconds
        DeltaT = .0003684

' Values for MetraByte DAS-4/8
      Control = &H302
      MaskIP3 = 64              ' 0100 0000
      OP3Low = 191              ' 1011 1111
      OP3High = 255             ' 1111 1111

' Graphics mode, clear screen
        SCREEN 2: CLS
' Scale screen for 600 points, 0 to 5 meters
        WINDOW (0, 0)-(600, 5)

' Plot 600 distance Vs time values
        FOR PulseNumber = 1 TO 600

' Start ranging: pull INIT low (OP3 = 0), then high (OP3 = 1)
        ControlByte = INP(Control)
        OUT Control, OP3Low AND ControlByte
        OUT Control, OP3High AND ControlByte

' Read ECHO (IP3)   (high = 64, low = 0)
' When IP3 goes high, ECHO has returned. Time interval between
' pulling INIT high and reading ECHO high is time it took for
' sound to travel from ranger to object and back.
        N = 0
        DO
        x = INP(Control) AND MaskIP3
        N = N + 1
        LOOP UNTIL x = 64

' Distance = Speed x Time. Then plot and delay.
        Distance = 345 * N * DeltaT / 2
        PSET (PulseNumber, Distance)
        FOR Delay = 1 TO 250: NEXT
        NEXT
```

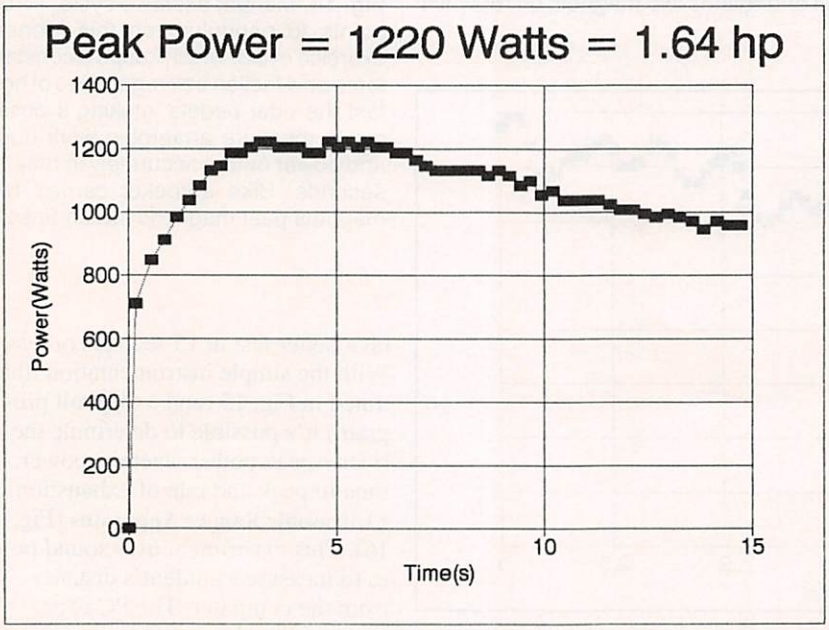


Fig. 15. During anaerobic ride on Monark cycle, power versus time always peaks within a few seconds and then declines steadily.

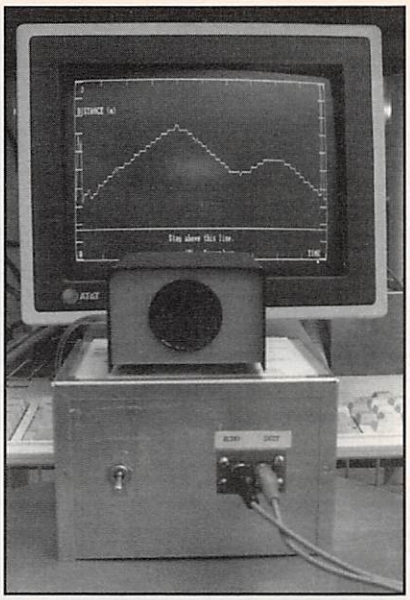


Fig. 16. Polaroid Sonic Ranger rests on battery box. PC uses distance measurements from Ranger to plot distance versus time.

walks toward and away from the PC (lead photo). The PC uses OP3 to send a pulse and IP3 to detect its echo. The RANGER0 program in Listing 4 shows how to do this. On the DAS-4/8 cards, programs read from the status register and write to the control register, and both occupy the same address (base address + 2).

Control register on DAS-4 & DAS-8

Bit Position	Meaning	OP3Low	OP3High
7	OP4	1	1
6	OP3	0	1
5	OP2	1	1
4	OP1	1	1
3	INT	1	1
2	X	1	1
1	X	1	1
0	X	1	1

Bit 3 of Control can generate interrupts. To prevent screwing up operations, RANGER0 reads Control and stores it as ControlByte. Then ControlByte is ANDed with the masks OP3Low and OP3High to send a pulse. This sequence preserves the value in Bit 3 of the control register.

The *QB* TIMER is adequate for finding T for this application because the DO...LOOP for reading IP3 executes 600 times, rather than only 10 as in the TIME-1 example. ■

By TJ Byers

Memory Managers Give Back Unclaimed User RAM

A memory manager can put to good use the unclaimed and otherwise wasted RAM memory lurking in your PC

Having computer memory is a lot like having money. Both are precious resources, and you can never have enough of either. And, like money, there's only so much memory to go around. When it's gone, it's gone. Fortunately, a good memory manager, just like a good money manager when it comes to finances, can stretch your RAM resources so that you won't be caught short. Here's how they work and a look at the leading products in this area.

Memory Organization

The problem we now experience in computer memory dates back to 1980, when IBM decided to build a personal computer. IBM wasn't the first company to try building personal computers, of course. Companies like Atari and Commodore preceded IBM in this arena and were seasoned players at the time of IBM's entry. However, since IBM had the clout, carried over from its mainframe-computer fame, and the money to capture the marketplace, it set the rules that remain in effect to this day.

Originally, IBM decided to give the PC a then-humogous 1M of user RAM (compared to the 64K typical of most competitors in those days), which it split down the middle. Allocation was 512K to the software applications and 512K was reserved for computer purposes. However, it soon became apparent that 512K for applications was too small. Software vendors—notably Lotus—complained loudly. So IBM grudgingly gave up 128K of its reserved memory to expand user RAM to 640K. Let's look at how this memory was and is now allocated.

• ***Upper Memory.*** The revised allocation leaves 384K above the 640K barrier that the PC's hardware can use for itself. This area goes by several names, including reserved memory and shadow memory, but DOS prefers to call it *upper memory*. Figure 1 and Table 1 show the structure of upper memory.

• ***Video Graphics Area.*** The first 128K is reserved for the video display. Starting at exactly 640K (hex A000) is a 64K area used for EGA (Enhanced Graphics Adapter) or VGA (Video Graphics Array) graphics display. Actually, most video cards support more than 64K of video memory built into the card itself, which is typically 1M for a VGA video controller.

However, the graphics card doesn't present all of its memory to the CPU all at once. There simply isn't enough room. Instead, it bank switches different pieces of its memory into this 64K area, as needed. Since the video card has its own on-board controller that can see all of the video memory at once, it uses bank switching only when the CPU upgrades or changes the image. Consequently, you can display higher screen resolutions than is possible using RAM.

• ***Text-Characters Area.*** Just beyond the video graphics area, starting at address 736K (hex B000), is 64K reserved for text information. This area is split in half, with the first 32K allocated to monochrome text and the latter 32K reserved for color text. The reason for the split is because it's possible to have both types of monitors running at the same time. Therefore, the memory for each of these cards has to be kept separate from the other.

Each character on the screen takes one byte of memory. Additionally, each character can be a different color and have a unique background color. These attributes are kept in a separate byte that's used to determine the color setup for each character. Four bits are used for the character's color, three bits are used for the background and one bit determines whether or not the character blinks, for a total of eight bits, or one byte.

Most text screens have 25 lines consisting of 80 characters per line. This accounts for 2,000 bytes of memory. Doubling this figure for the attributes brings the total to 4,000 bytes. Even when a screen is using more lines (a VGA can display 50 lines in character mode), it's apparent that a lot of the text memory area goes unused.

Actually, the rest of the 32K is reserved for storing other text screens. By saving extra screens in memory,

Table 1. The Reserved Memory Area

Location Name	Size	Hex Address	Decimal Address
EGA/VGA Graphics	64K	A000 Thru AFFF	640K
Text Memory (Mono)	32K	B000 Thru B7FF	704K
Text Memory (Color)	32K	B800 Thru BFFF	736K
Video ROM	32K	C000 Thru C7FF	768K
Other Device Area	96K	B800 Thru DFFF	800K
Reserved BIOS	64K	E000 Thru EFFF	896K
System BIOS	64K	F000 Thru FFFF	960K
Total	384K		

it's possible to quickly switch from one text page to another. However, very few programs use this feature.

• ***Video ROM.*** Like the CPU, the video controller requires a BIOS program to keep things straight. The program, that contains the fonts and video program calls is contained in a ROM located on the video card. Unfortunately, ROM-based programs run very slowly. So the next block of upper memory is set aside for the video BIOS. By coping the video BIOS from ROM to faster RAM, the video instructions run at faster CPU speed. The reserved area starts at 768K (hex C000) and consumes 32K of RAM.

• ***No-Man's Land.*** The next 96K of RAM, from 800K (hex C800) to 896K (hex E000), isn't assigned to any particular device. It's basically used as a catch-all for your hardware peripherals to use. Special devices—such as network controllers, CD-ROMs and sound cards—often make use of this memory.

Generally, it's first come, first served. Which presents a problem when two devices attempt to use the same address. When this occurs, it becomes necessary to change one or the other's hardware address, using onboard jumpers or configuration software. An easy way to determine if the problem is a hardware address conflict is to run a diagnostic program such as the *Norton Utilities* or DOS's MSD utility.

• ***System BIOS.*** The last 128K of upper memory is used by the system BIOS. The first 64K (896K decimal, hex E000) of this area was originally reserved for an unspecified BIOS upgrade. At first, it was speculated that vendors would place applications in a ROM that could plug into an extra ROM socket on the motherboard and boot the application on power up. This never really caught on. Vendors were afraid to put a device there in case IBM came out with a new BIOS that would instantly make all PCs that used this area incompatible. As it turns out, IBM did capture the space for its PS/2 video BIOS, which is 64K wide, rather than the 32K of PC/AT video. But basically it goes wanting.

The last 64K begins at 960K (hex F000) and contains the system BIOS. Like video BIOS, system BIOS runs faster with system RAM than it does in ROM. On genuine IBM PCs, not clones and compatibles, a portion of the BASIC program code is also placed here.

Conventional Memory

Virtually all applications—including a portion of *Windows*—load into conventional memory below 640K. The amount of memory the program requires varies considerably. Some, such as *AutoCAD,* need it all. Others use only a small portion of it. When you don't have enough memory, the application simply won't load.

Actually, 640K is enough RAM for most applications. The problem is that device drivers and TSR (terminate-and-stay-resident) programs take their share of system memory long before the application is loaded. For example, the first 1.8K is used by DOS for interrupts, BIOS data and system data. SmartDrive uses 28K, the mouse driver uses 17K and each DOS buffer consumes 528 bytes (30 buffers equals 15K). As you can see, it doesn't take long for the first 640K of RAM to disappear. Before you know it, the dreaded "Out of memory" message is staring you in the face.

The remedy is to free up more memory for application use. One way is to remove TSR device drivers. But this isn't practical if you need the utilities. A better method is to find unused areas of RAM—such as the empty spaces in upper memory—where the device drivers and TSRs can be placed.

Memory Managers

If you have a computer with a 286, 386 or 486 CPU, you may be able to free conventional memory by using a memory manager to move your TSRs into the upper memory area. The unused areas of upper memory are called *upper memory blocks*—UMBs, for short.

The memory manager marks the UMBs by mapping extended memory to the unused addresses in the upper-memory area. These addresses are then made available to TSR programs, such as SmartDrive. The memory manager matches the size of the program to the size of the UMBs and decides where each program should be placed. A good memory manager can free up to 224K of extra memory.

Bear in mind that DOS likes to load programs in one contiguous piece. And the available UMBs aren't grouped together in one big chunk. They're scattered throughout the upper-memory area. Therefore, it's most efficient to load programs that require more memory before programs that require less memory. If you don't, several small programs can use up a big block of memory before a larger program is measured for a fit, thus preventing the larger file from loading into UMB.

Some memory mangers, such as Microsoft's MemMaker, use a simple first-come, first-served approach that makes no attempt to optimize the loading order. Other memory managers try to fit the pieces for best UMB usage by intelligently ordering their loading sequence. Intelligent memory managers can actually move the video and BIOS areas around in upper memory to create large blocks of contiguous UMB space.

If high-resolution graphics aren't required, as is the case with DOS-based Lotus *1-2-3* and *dBASE* IV, most memory managers can open up to 96K of additional memory by freeing the video memory just beyond 640K. You gain 64K if you have an MDA, Hercules or EGA/VGA (monochrome) adapter and 96K if you have a CGA or EGA/VGA (color) adapter. Because this memory area is located just above the 640K limit, it behaves exactly like conventional memory, not a UMB.

DOS applications aren't limited to 640K of RAM. It's the PC that is. By opening up this section of contiguous memory, any DOS program can use it just like it would memory between 0 and 640K, but now the limit is a hefty 736K. Be aware that this area must be reclaimed before you can run graphics.

The following is a look at the memory managers on the market today and how each works. This survey includes *386Max* Version 7, IBM PC-DOS 6.1's RAMBoost, *Memory Commander* 4.07, Microsoft MS-DOS 6.x's MemMaker, *NETROOM 3*, Novell DOS MemMax 7.0, *QEMM-386* Version 7. While each works differently, they all have several things in common.

An example of commonality is that all of the products reviewed here are surprisingly close to each other in price. List prices vary by less than a dollar and range from $99 to $99.99.

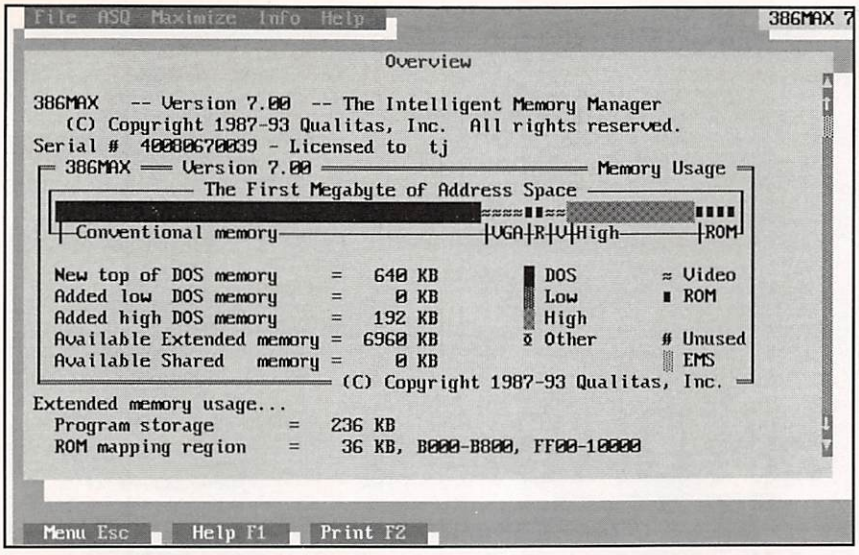


Fig. 1. Unlike most memory managers, whose menus are strictly text oriented, *386Max* adds a small element of graphics to its screens.

However, street prices vary considerably, with *QEMM-386* selling for as little as $59. The memory managers bundled with MS-DOS, IBM PC-DOS and DR DOS are included with the DOS and can be considered "free" utilitities. Unfortunately, since you usually get what you pay for, they aren't as powerful as their commercial counterparts.

All the memory managers tested come with an installation program that automatically installs and sets up each product. Some memory managers do a very thorough job of organizing files and UMB space for maximum efficiency. Others aren't so ambitious, leaving you to do the detail work for them. All have a menu-driven custom setup program that lets you fine-tune the memory environment.

Once installed and configured, these memory managers transparently do their jobs with no further user input—unless you make changes to your system or software. Here's how they look individually.

386MAX Version 7

The *386MAX* package from Qualitas (Fig. 1) runs on most 386, 386SX and 486 PCs with 256K or more of extended memory. This application includes a sophisticated program that automates the installation and configuration process. The first part of the process is a menu-driven questionnaire, where you're asked questions about your system. Interactive on-line help is available during the installation.

The next step of *386MAX* setup is done using the Maximize utility that can be activated from the installation menu. First, Maximize examines your CONFIG.SYS, AUTOEXEC.BAT and other batch files to locate device drivers and TSR programs. When Maximize finds TSR software, it determines how much memory the software requires.

Some programs take a larger amount of RAM when they're launched than they do once they're underway. For example, DOS's FASTOPEN has an initialization size of about 68K, which reduces to just 3K when it becomes resident. To get the most from the UMBs, Maximize measures a program's memory needs during both phases of its execution and stores the information in a data file.

In addition to the above, Maximize can determine the best order in which to load device drivers and TSRs, since one loading order may use memory more efficiently than another. It does this by trying every combination and testing it for maximum efficiency. For example, suppose there are five resident programs and two areas of UMBs. Maximize will run through 3,840 loading combinations before deciding on the best one. After choosing the best configuration, Maximize modifies the startup files with the new loading order and settings. ExtraDOS is a *386MAX* utility that can load FILES, BUFFERS, FCBS, LASTDRIVE, STACKS, and COMMAND.COM into the *high memory area* or the HMA, which is the first 64K beyond 1,024K, for even more conventional memory.

If you don't need high-resolution graphics, Maximize can expand the conventional memory area up to 736K by freeing the video memory space when using a CGA, EGA or VGA color monitor. Maximize can also relocate the VGA video BIOS to create a large contiguous UMB region for device drivers and TSRs. Both options can be added, using the text editor included in the *386MAX* User Interface menus. When the configuration and setup process is complete, your CONFIG.SYS, AUTOEXEC.BAT and related batch files are modified.

If you have a 286 PC that uses the NEAT, AT/386 or LEAP CHIPset from Chips & Technologies, *386MAX* has a memory manager for it. These CHIPsets have 384K of RAM (called shadow RAM) that parallels the motherboard's upper-memory area. *386MAX* determines which areas of upper memory aren't in use and then automatically enables the shadow RAM at these addresses.

Memory Commander 4.07

When it comes to expanding the 640K envelope, nobody does it better than *Memory Commander* from V Communications (Fig. 2). Under ideal conditions, contiguous conventional RAM can be expanded to 800K for running VGA graphics and to a whooping 920K for running VGA text applications. *Memory Commander* works with all 386 and 486 PCs that have at least 512K of extended memory.

Memory Commander works on a unique memory-management technique that permits devices in upper memory to float. As the need for contiguous conventional RAM increases, *Memory Commander* pushes such devices as video display memory, BIOS ROMs and hard-disk ROM up to 1M as far as possible (see Fig. 2). For example, you can raise the conventional RAM limit to 780K by simply moving the video buffer and video BIOS from 640K (A000) into the vast UMB wasteland below 896K. Additional memory can be gained by reducing the memory requirements of the video programs.

Memory Commander has five memory modes in which DOS applications can run. Each mode performs progressively more-aggressive memory remapping to give you more contiguous conventional RAM. The actual amount of low memory available in each mode depends on the components of your system. If you permit *Memory Commander* to automatically load and optimize your device drivers and TSRs into upper memory, you'll likely see less conventional RAM available.

With *Memory Commander*, the best memory mode for one application may not be the optimum memory mode for another. Instead of making changes to your CONFIG.SYS and AUTOEXEC.BAT files, *Memory Commander* has an application database that automatically keeps track of the memory mode and setup parameters that are right for each of your applications. To get you started, the database comes with settings for some popular applications. Programs can be added and deleted and the parameters modified using *Memory Commander*'s menu-driven Control Panel.

Once installed, *Memory Commander* runs in the background, maintaining a watch on your memory resources and needs. When a program is started, *Memory Commander* checks the database for the correct configuration and makes whatever changes are necessary on the fly. You don't have to re-boot your system for the changes to take effect, as you do with other memory managers.

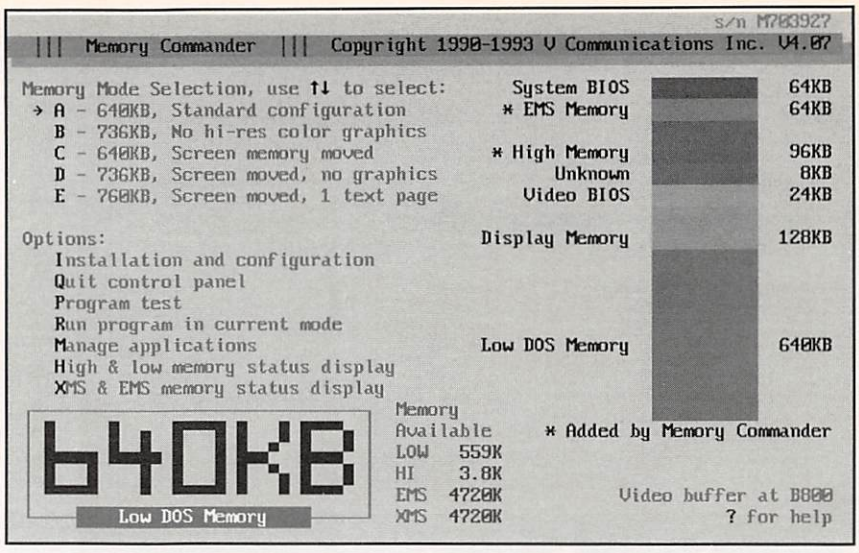


Fig. 2. *Memory Commander* has five memory modes in which DOS applications can run. The standard mode is shown above.

Microsoft MemMaker
(Part of MS-DOS 6.x)

MemMaker is the Microsoft memory manager that ships with DOS 6.0 and 6.2. It works with most PCs that have a 386 or 486 CPU and extended memory beyond 1M. Like most Microsoft products, MemMaker has two setup procedures: Express and Custom. As the name implies, Express requires almost no user intervention to install. MemMaker is specifically written for MS-DOS 6.x, and the default choices in the Express setup can generally optimize your system's memory.

In some systems, MemMaker can gain more conventional memory if you choose the menu-driven Custom setup option. Custom setup walks you through a list of menus that let you configure the setup to free additional memory (Fig. 3). For example, if you have an EGA or VGA monitor, you can free the 64K of upper memory in the 736K to 768K range (hex B000 to BFFF) set aside for monochrome and color text. You can also disable expanded memory, if installed, to free another 64K of UMBs in the 896K to 960K area (hex E000 to EFFF).

To install MemMaker you have to re-boot your PC. As each device driver and TSR program starts, MemMaker determines the program's memory requirements by monitoring how it allocates memory. In the process, MemMaker may consider thousands of possible memory configurations before selecting the most-efficient one. When the calculations are complete, MemMaker makes the necessary changes to your CONFIG.SYS and AUTOEXEC.BAT files.

How The DOSes Compare

Since every DOS comes with its own memory manager, you're probably wondering how they compare to each other. Is one DOS's memory manager better than another? Here's what we discovered.

The easiest to install are IBM PC-DOS 6.1's RAMBoost and Microsoft's MS-DOS 6.x's MemMaker. Novell DOS is fairly difficult to install because the defaults don't work with *Windows* and graphics applications. Consequently, you have to make editing changes before you can use it. This is really a shame because Novell DOS has the worst editor of the lot and requires a fair amount of manual file editing. When it came to editing, MS-DOS's MemMaker has them beat, hands down. The options are few and easily understood. PC-DOS's RAMBoost's editor is powerful and easy enough to use, but you'll need the aid of the information given in Table 1 in the main article to assure success.

Thanks to an intelligent algorithm, RAMBoost does the best job of increasing the size of conventional memory space for *Windows* and graphics applications. Novell DOS and MemMaker are nearly tied at about 100K behind RAMBoost. When gaining ground for such text-based applications as *dBASE IV*, Novell DOS and RAMBoost are virtually neck and neck. MemMaker runs far behind the pack because it's editor doesn't have the options you have with the other two.

MemMaker and RAMBoost are very well-behaved memory managers. With the exception of not being able to run graphics applications when upper memory video is reassigned, all software runs flawlessly. Novell DOS, on the other hand, is constantly at odds with software applications. We got memory address conflicts more than once during our testing, conflicts that can be cured only by manually editing the configuration files one more time.

Of course, the commercial packages can open up more room, and they come bundled with other goodies. But they can't beat the price of the DOS utilities. In some cases, the few kilobytes gained may not be worth the effort it takes.

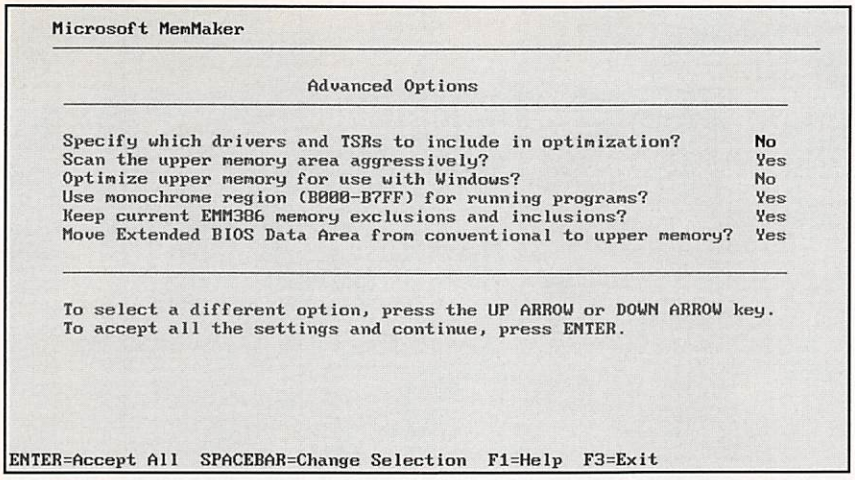


Fig. 3. DOS 6.x's MemMaker program is among the easiest to install, but the custom configuration options are limited.

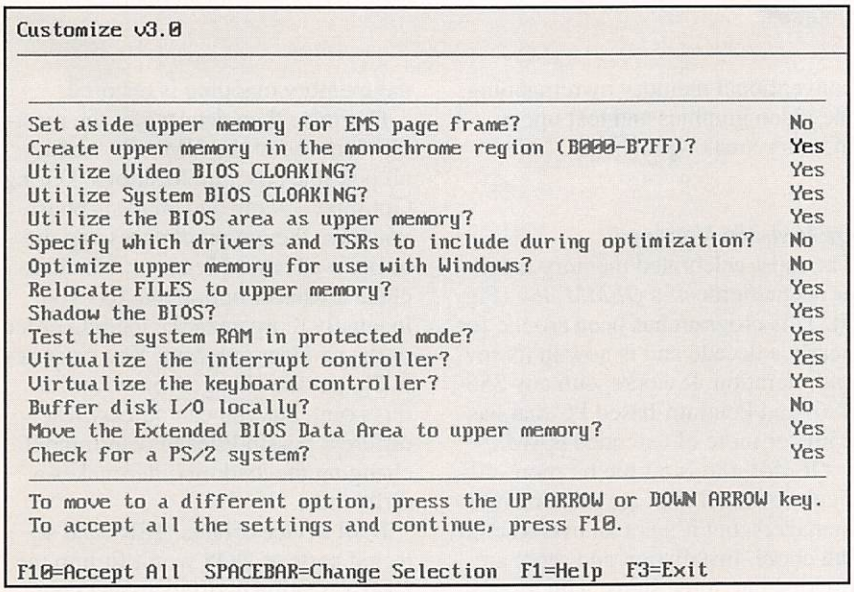


Fig. 4. Using *Netroom 3*'s configuration program is a simple matter of choosing yes or no from the above menu.

MemMaker is the least-sophisticated of the memory managers. Although MemMaker fits your device drivers and memory-resident programs as efficiently as possible in the available UMB slots, it doesn't change the order in which these drivers and programs appear in the CONFIG.SYS and AUTOEXEC.BAT files. To make better use of UMB, you have to manually arrange the files by size, using a text editor before you run MemMaker.

Also, MemMaker doesn't test for errors. After installation, MemMaker displays a screen that prompts you to specify whether your system appears to be working properly. If not, you have to run the Undo command and try again using Custom setup.

Netroom 3

Netroom 3, from Helix Software (Fig. 4), is a unique memory manager that permits programs to run in 32-bit protected mode, yet still remain DOS-compatible. Based on revolutionary "Cloaking" technology, *Netroom* can free up to 240K of upper memory without the performance hit experienced with older 386 memory managers. The program is compatible with all Intel CPUs, including 8088/8086, 286, 386, 486 and Pentium, with 1M of system RAM plus EMS or extended memory beyond 1M.

Netroom is a mixture of several memory-saving technologies. Conservative mode is the least-robust and compares favorably with Microsoft's MemMaker. It simply examines upper memory for free UMBs and fits device drivers and TSRs into the open spaces as best it can. And like MemMaker, it makes no attempt to organize the loading order of the programs for maximum efficiency. You have to do this manually.

Unlike MemMaker, *Netroom*'s Conservative mode supports 286 PCs that have the Chips & Technologies NEAT chipset, plus 8088, 8086 and 286 PCs that have EMS hardware adapters. There's also a utility that lets you relocate BUFFERS, FCBS, FILES, LASTDRIVE, STACKS and DOS into the HMA beyond 1M.

The highlight of *Netroom*, though, is its Cloaking technology that provides the ability to run device drivers, TSRs and ROMs in 32-bit protected mode (using a 386 or 486 CPU) under DOS and *Windows* 3.1. The Cloaking process works by loading a pointer code in conventional memory (usually less than 1K) and loading the program itself in extended memory beyond 1M. No upper memory is used to support relocation of the Cloaked program, and no file swapping or memory movement takes place. The program actually runs in extended memory. However, the program must be written to be aware of Cloaking so that *Netroom* links to its own memory manager.

The programming process is a simple matter of inserting an API code at the beginning of the application. But you need the source code and its related compiler, which means it's highly unlikely that you can modify your current applications for Cloaking.

Fortunately, *Netroom* comes with an assortment of Cloaking utilities. Among them are a Cloaking system BIOS and video BIOS from Award Software. If you use these Cloaking BIOSes instead of your own, they occupy just 8K of system RAM instead of the typical 96K. The extra 88K becomes available as UMBs. To illustrate how it works, recall that most PCs locate the system BIOS between 960K and 1M (hex F000 and FFFF). Using the *Netroom* Cloaking system BIOS, 60K is freed. A small 4K area

at 1,020K (hex FF00) contains tables and BIOS information required by DOS programs. The remainder of the BIOS is located and running in extended memory beyond 1M.

Another advantage of using the *Netroom* BIOSes is that, unlike a ROM chip, they're easily updated via new software. This is like getting a free BIOS upgrade for your PC. However, the current version of *Netroom*'s video BIOS doesn't fully support super-VGA graphics. At high resolutions, screen colors are often limited to just 16 instead of the 256 or better you get with your video adapter's BIOS. Other bundled Cloaking software includes virus protection, a screen-saver utility, a disk cache, a RAM drive and a screen accelerator, to mention a few.

Like most memory managers, *Netroom* has an advanced-setup program that lets you customize your RAM. It can provide up to 736K of contiguous conventional memory by remapping the video graphics and text upper memory area.

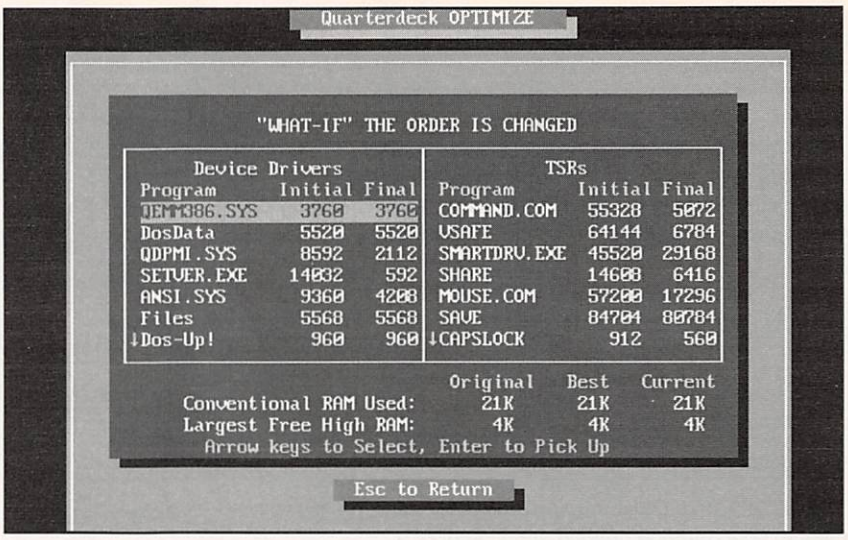


Fig. 5 . While *QEMM-386* doesn't automatically reorder file loading, it uses a what-if scenario that lets you see what would happen if you arranged them by yourself.

System Memory Defined

Conventional Memory starts at 0K and normally ends at 640K. This area also goes by the names of base memory and low memory and is where most DOS programs run.

Upper Memory starts at the end of conventional memory—traditionally 640K—and ends at 1,024K (1M). Normally, this area is reserved for use by the system and video ROM, video data and hardware adapter cards, such as network adapters and sound cards. However, much of this space remains unclaimed and, thus, can be used to store device drivers and TSRs, using a memory manager.

Extended Memory is the memory addresses beyond 1,024K (1M). It's used by programs operating in protected mode, such as *Windows*, and can extend to 64M and beyond in 386 and 486 systems (286 extended memory is limited to 16M).

High-Memory Area (HMA) is the first 64K of extended memory. Some programs, most notably DOS, can use this area in which to store a portion of their code to free up conventional memory.

Expanded Memory (EMS) is memory beyond the first megabyte of RAM memory. Before the advent of the 386 CPU, this was the *only* way to use memory beyond 1,024K. Access to this memory requires an expanded-memory manager, such as *QEMM* EMS access is done through a 64K window that's located in upper memory.

QEMM-386 Version 7

The most-celebrated memory manager is Quarterdeck's *QEMM-386* (Fig. 5). This program has been around for nearly a decade and is now in its seventh iteration. It works with any 386-, 486- and Pentium-based PC that has 256K or more of extended RAM.

QEMM-386 is a little bit more-difficult to install than are most memory managers, but it's not an overwhelming chore. Installation and setup are divided into three steps, with a separate program used for each. The first program simply loads the *QEMM* software on your hard disk and readies your system for the second step, which is actual optimization, using an Optimize utility.

Optimize analyzes your system to determine the most-efficient way to use your PC's upper memory area. Since some device drivers and TSRs use more memory to initialize than they do once they're in memory, Optimize notes the differences.

If an item needs a larger amount of memory to initialize than is available in a contiguous chunk, Optimize may use a Squeeze feature that temporarily maps over a ROM, adapter RAM, excluded area or EMS page frame to make a large enough contiguous area. After the program is initialized, original memory mapping is restored.

Optimize then determines the most-efficient use of the UMBs by testing all possible program locations. During Optimize's setup and analysis phase, you have the option of accessing the utility's advanced features, which include a what-if option that lets you manually reorganize the loading order of the resident program. You can't actually put the changes into effect at this point, but you can quickly test different possibilities to determine if changing the loading order makes a difference.

If all device drivers, TSRs and selected parts of DOS won't fit into the UMBs, Optimize offers to test your system for Stealth compatibility. Stealth ROM creates additional mappable areas at the addresses used by your PC's BIOS ROM, video ROM and disk ROM (network and certain controller ROMs my be included as well).

Because of differences in the manner in which system hardware and software deal with ROMs, Stealth ROM can be implemented using one of two methods: the mapping method and the frame method. Both methods monitor the interrupts pointing to these ROMs, and both require EMS memory.

Stealth ROM mapping works by moving the ROM's contents to extended memory above 1M. When the system needs the ROM by issuing an interrupt, QEMM copies the appropri-

ate ROM code into the 64K EMS page frame that gives the ROM code a valid real-mode address at which it can execute. When the ROM routine completes, *QEMM* removes the ROM code from upper memory.

Stealth ROM framing leaves the ROMs in their original upper memory location. *QEMM* then places the EMS page frame *over* the ROM area so that it lies on top of the ROM's address space. When the ROM is needed, *QEMM* saves the contents of the current page frame and makes the ROM's addresses available. The ROM code then executes normally. When the ROM routine is finished executing, *QEMM* restores the previous contents of the page frame.

With the ROMs out of the way, the amount of usable upper memory is greatly increased. The mapping method can add 83K to 115K of extra UMBs to the upper-memory area, and the frame method provides 48K to 64K of extra UMBs. However, Stealth ROM doesn't work with all systems and software applications, and it doesn't have error checking. When a problem occurs, you have to locate the culprit using trial-and-error methods.

Like most memory managers, *QEMM* can free up the video graphics and text areas to extend contiguous conventional memory up to 736K. It can also relocate BUFFERS, FCBS, FILES, LASTDRIVE, STACKS and COMMAND.COM to the HMA that lies beyond 1M.

IBM RAMBoost
(Part of PC-DOS 6.1)

Of the memory managers that come bundled with DOS, PC-DOS's RAMBoost (Fig. 6) opens up the most conventional memory space for *Windows* and graphics applications. PC-DOS is IBM's answer to MS-DOS 6.0. After listening to MS-DOS 6.0 users, IBM fine-tuned the utilities and marketed them as DOS 6.1.

IBM's RAMBoost memory manager is licensed from Central Point, the makers of *PC Tools*. RAMBoost is an easily installed program. It has a learn mode that searches your CONFIG.SYS and AUTOEXEC.BAT files for device drivers and TSRs. While you sit and stare, it does an excellent job of fitting your device drivers and TSRs into upper memory. In fact, when it finished with our benchmark, just 6K of UMBs were left unclaimed.

While IBM's RAMBoost program can't shuffle the contents of the upper memory area, you can do it manually in 4K chunks, using the table shown in Fig. 6. For example, marking the first eight blocks of the second line (Bx00) as unused gains you 32K. However, unless you know upper memory by heart, you'll need the road map contained in Table 1 to find your way around.

Like all memory managers that come bundled with DOS, RAMBoost makes no attempt to optimize the loading order of the files. You have to do this manually. And while extended memo-

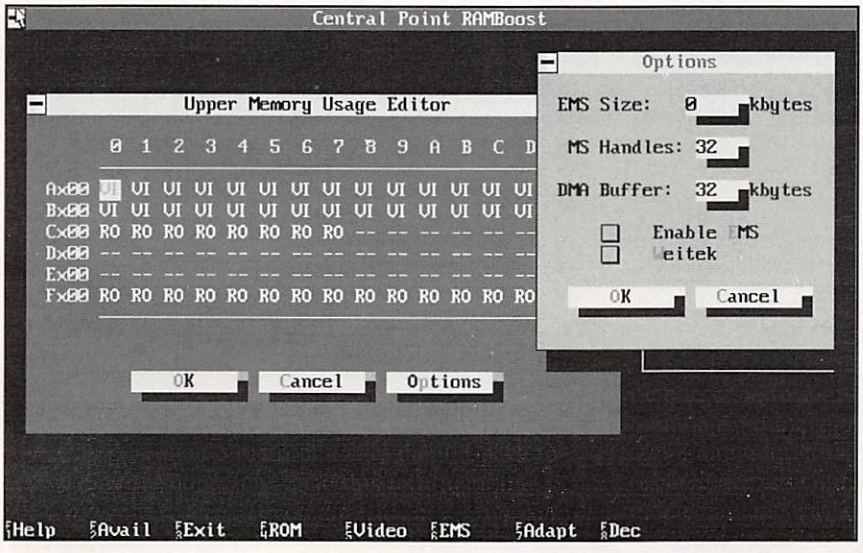


Fig. 6. While IBM's RAMBoost program can't shuffle the contents of the upper memory area, you can do it manually using the table above.

ry isn't required, RAMBoost will locate DOS in HMA if it's available.

Novell DOS 7.0

Formerly known as DR DOS, Novell DOS is marketed as an enhanced alternative to MS-DOS. Until MS-DOS 6.0 came along, Novell's memory manager (Fig. 7) was the only alternative to such commercial products as *QEMM-386*. It supports most 286-, 386- and 486-based PCs, and it doesn't need extended memory to enhance conventional memory space.

If your computer has extended memory, you can make more conventional memory available by running the DOS software in HMA. Extended memory can also be used for expanded memory using the EMM386 utility.

When Novell DOS is first installed, it makes no attempt at optimizing memory usage. You have to do this by running Setup and manually editing your CONFIG.SYS and AUTOEXEC.BAT files.

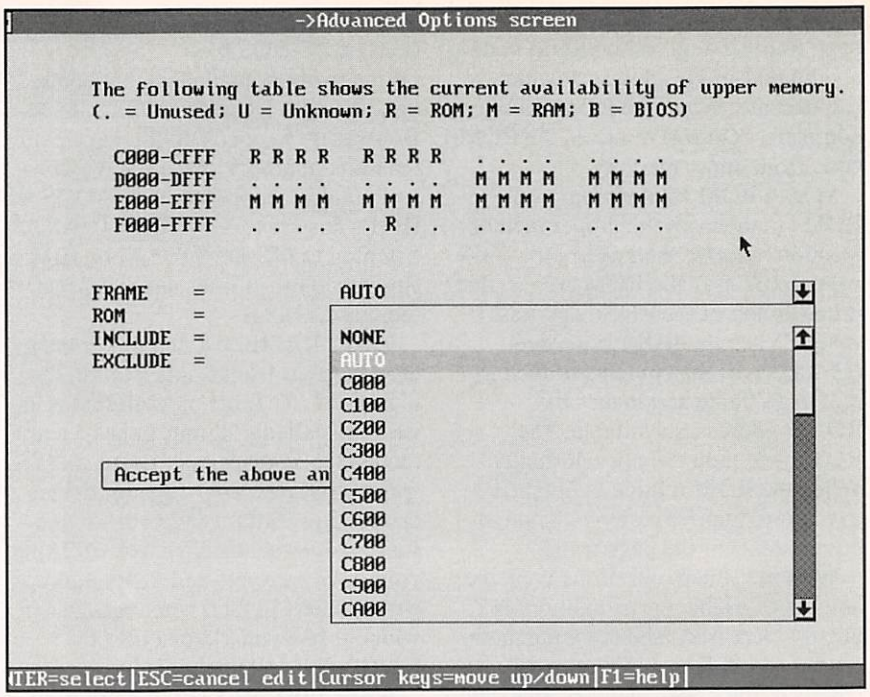


Fig. 7. Novell's Setup program has an Advanced Options screen that lets you specify particular memory areas from which to copy ROM to RAM.

Table 2. Memory-Management Utilities Comparison Chart

Standard Features	386MA X7.0	Memory Commander 4.07	NETROOM 3	QEMM-386 7.03	RAMBoost	MemMaker	Novell DOS7
List Price	$99.95	$99.95	$99	$99.95	$189	$77.90	$99
On-Line Help	Y	Y	Y	N	Y	Y	Y
Undo	N	Y	Y	N	N	Y	N
Supports 80286 PCs	N	N	Y	N	N	N	Y
Crash-Proof Installation	N	Y	Y	N	N	Y	N
Backfill UMBs to Reach 640K	Y	Y	N	N	N	N	N
Memory-Management Features							
Conventional Memory Free	425K	425K	425K	425K	425K	425K	425K
Start	628K	679K	620K	634K	584K	445K	499K
After Automatic Setup	628K	679K	620K	634K	605K	491K	611K
Text-Based Applications	628K	679K	619K	630K	584K	481K	499K
Conventional Memory Gain	**203K**	**254K**	**195K**	**209K**	**180K**	**66K**	**186K**
Contiguous RAM Beyond 640K	Y	Y	Y	Y	N	N	Y
Automatic Load Ordering	Y	Y	Y	N	N	N	N
Loads Drivers/TSRs in Upper Memory	Y	Y	Y	Y	Y	Y	Y
Loads Drivers/TSRs in HMA	Y	Y	Y	Y	N	N	N
Loads Drivers/TSRs in Expanded Memory	N	Y	Y	Y	N	N	N
BIOS Compression	N	Y	Y	N	N	N	N
Unused BIOS Automatic Detect	Y	Y	Y	N	N	N	N
Included Utilities							
Text Editor	Y	Y	Y	Y	Y	Y	Y
Disk Cache	Y	N	Y	N	Y	Y	Y
RAM Disk	Y	N	Y	N	Y	Y	Y
ANSI Driver	N	Y	N	N	Y	Y	Y
Virus Protection	Y	N	Y	N	Y	Y	Y
Screen Saver	Y	N	Y	N	Y	Y	Y
Windows Utilities	Y	N	Y	N	Y	Y	N
Comprehensive System Analysis	Y	Y	N	Y	N	Y	N

*Included with IBM's PC-DOS 6.2 at no extra charge. List Price is for entire DOS package.
**Included with Microsoft's MS-DOS 6.x at no extra charge. List Price is for entire DOS package.

Products Mentioned

NETROOM 3
Helix Software
47-09 30 St.
Long Island City, NY 11101
Tel.: 718-392-3100
CIRCLE NO. 136 ON FREE INFORMATION CARD

IBM PC DOS RAMBoost 6.1
IBM Corp.
White Plains, NY 10604
Tel.: 800-342-6672
CIRCLE NO. 137 ON FREE INFORMATION CARD

MS-DOS MemMaker 6.2
Microsoft Corp.
One Microsoft Way
Redmond, WA 98052
Tel.: 206-882-8080
CIRCLE NO. 138 ON FREE INFORMATION CARD

Novell DOS MemMax 7.0
Novell, Inc.
122 E. 1700 S.
Provo, UT 84606
Tel.: 801-429-7000
CIRCLE NO. 139 ON FREE INFORMATION CARD

386Max Version 7
Qualitas
7101 Wisconsin Ave. #1386
Bethesda, MD 20814
Tel.: 301-907-6700
CIRCLE NO. 140 ON FREE INFORMATION CARD

QEMM-386
QuarterDeck Office Systems, Inc.
150 Pico Blvd.
Santa Monica, CA 90405
Tel.: 310-392-9851
CIRCLE NO. 141 ON FREE INFORMATION CARD

Memory Commander
V Communications, Inc.
4320 Stevens Creek Blvd. #275
San Jose, CA 95129
Tel.: 408-296-4224
CIRCLE NO. 142 ON FREE INFORMATION CARD

Actually, Novell doesn't have one encompassing memory manager, like DOS's MemMaker. Rather, it's composed of elements from several commands. The Setup utility provides a quick and easy way of changing the system configuration any time after it has been installed. For example, the memory manager can automatically copy data from slow ROM to faster RAM. The ROM-copy option can be specified via the Setup utility. To avoid conflict, the default setting ensures that the RAM and copied ROM have the same address. If you want to specify particular memory areas from which to copy ROM, Setup has an Advanced Options Screen (see Fig. 7).

For some advanced configuration changes, you may need to edit the configuration files directly, using the DOS EDIT utility or some other text editor. Using a MemoryMax utility to free the video graphics portion of upper memory for use as contiguous conventional memory beyond 640K is an example.

Summing Up

As you can see, memory managers—whether they're included "free" with the DOS you buy or are purchased as after-market utilitities—do, indeed, return precious unused low RAM memory for use by your programs. The one you use depends a lot on how much memory you want returned to you and how much effort you wish to invest. Refer to the Comparison Chart given in Table 2 for capsule summaries of what each product mentioned in this review offers and how each stacks up against the others. The bottom line, of course, is that all seven of the products mentioned are definite assets you should consider in your everyday computing. ■

By Hardin Brothers

Tuning Up Your Computer

Tips for getting your PC to deliver its maximum speed under DOS and *Windows*

I have a friend who told me that her 50-MHz 486 computer seemed to be operating slow, at least by comparison to the 25-MHz 386 machine on the next desk. Before I even looked at the two computers, I knew that her computer needed a tune-up. Unless her 486 was suffering from some obscure hardware problem, it was simply set up incorrectly and was bogging itself down.

You wouldn't drive a car with bad timing, incorrect fuel mixture in the carburetor and sticking choke. But many users let their computers suffer similar problems. Only when they notice how easily other computers pass them by in terms of operaing speed do they think of taking some action. But it's sometimes difficult to know where to start.

Most of the computers I see are running at less-than-peak efficiency and can benefit from a tune-up. DOS and *Windows* are both complex systems of software with thousands of options. If you make a few errors in your configuration files, your computer will run more slowly that it should.

There are literally hundreds of ways to fine-tune your computer. Some are specific to particular hardware or unusual interactions between software. When I tune up a computer, however, I always start with the same general techniques and work from there. The suggestions I present in this article boosted my friend's computer performance to its intended and anticipated speed. They can probably improve the performance of your computer as well if you give them a try.

Speedy Search Files

The first thing I look at on any computer is its AUTOEXEC.BAT file. If the computer runs *Windows*, I make sure that SHARE is installed in this file to protect the file system in case two DOS or *Windows* programs attempt to update the same file simultaneously. Microsoft strongly recommends that share be used on *Windows* systems, but most users ignore this suggestion.

Next, I look at the PATH setting. Nearly every DOS and *Windows* program I've installed on a computer wants to make a change to the AUTOEXEC.BAT file. Normally, the program wants to add its own subdirectory to the PATH statement. Rarely, it wants to make other changes as well.

These programs are only trying to make themselves easier for novices to use. But the result of their "kindness" is a slower, less-efficient computer. To understand why this is so, consider what happens if you type DUR instead of DIR at the DOS prompt. All of your commands are interpreted by a program called COMMAND.COM, which first looks at its internal list of commands that include such things as DIR, COPY and DEL. If the command you type at the keyboard isn't in this list, COMMAND.COM looks in every directory in the PATH for a .COM, .EXE or .BAT file with the appropriate name. If the PATH search fails, COMMAND.COM finally displays a "Bad command or file name" message on your video display monitor's screen and then waits for you to enter a new command.

Now assume for the moment that you have 10 subdirectories in your search path and that there's an average of 2,000 files in each directory. When you type DUR, COMMAND.COM has to spend the time switching from directory to directory and searching through 2,000 file names looking for DUR.COM, DUR.EXE or DUR.BAT. It can report that you've mis-typed the command name only after it fails to find a file with one of these names.

You can considerably speed up DOS by shortening the search path to two or three crucial directories, and you can do so without giving up the convenience of a long PATH statement. One way to do so is to include a batch file with the name you want to use for each program. For example, if you have a program called DEF.EXE that's stored in the C:\APPS\ABC subdirectory, you can create a file called DEF.BAT that changes to the correct subdirectory and runs your program. Your DEF.BAT program might look something like this:

```
@echo off
cd c:\apps\abc
def.exe
cd c:\
```

A faster and more-efficient way to run your major applications is to use the DOSKEY program included with DOS Versions 5.0 and 6.x.To create a macro equivalent to the above batch file, you could use the following command:

```
DOSKEY def+cd c:\apps\abc $T def.exe
```

Using a macro is faster than running a batch file because the macro is stored in memory and doesn't require disk access for each command.

Once you have all of your major applications running from batch files or DOSKEY macro commands, save them to a file with the command:

```
DOSKEY /M > macros.bat
```

Then edit the file, adding the command word DOSKEY before each line. Finally, change the PATH statement in your AUTOEXEC.BAT file to include only three or four essential directories like this:

```
PATH C:\DOS;C:\BATCH;C:\UTIL;
C:\WINDOWS
```

Finally, add the command: CALL MACROS.BAT to your AUTOEXEC.BAT file to load the macro commands every time you boot or re-boot your computer.

Just by doing the foreging, you've eliminated DOS's need to search perhaps dozens of directories for each application name. More importantly, you've taken the first giant step toward having a more-efficient computer.

Speed Up Disks

The weakest link in any computer is its disk drives. They're the least-reliable and slowest element of the system simply because they depend on mechanical operations as well as electrical ones.

There are a half dozen ways to speed up the disk system in your computer. The most common is to run a defragmenting utility regularly, possibly as part of your backup regimen. If each file on your hard disk is in one contiguous piece, instead of being spread out all over the disk, each file access will be much faster. The DEFRAG utility included with DOS 6.x works well, as do many commercial and shareware defragmenting utilities.

On computers that are more than three or four years old, setting proper interleave is crucial. The interleave determines how the sectors are arranged on the disk. If the interleave is set correctly, each sector appears under the read head just as the computer is ready to read it. If it's set incorrectly, the computer must wait for the sector to appear under the head. In a worst-case scenarion, an incorrect interleave can slow data transfers by a factor of 16.

Interleave is normally set during low-level formatting of the hard disk. In the past, setting the interleave was a hit-or-miss proposition. You had to save all of the data on the disk, perform both low- and high-level formats to set a new interleave and then copy the data back onto the disk. Then you had to experiment to see if the new interleave was faster or slower than the old value. Modern programs like Gibson Research"s *SpinRite* and Symantec's *Norton Utilities* can now calculate the correct interleave and change a hard drive's interleave setting without requiring a low-level format. If your computer has an IDE or SCSI hard-disk controller, you don't need to worry about the interleave setting at all.

For day-to-day operations, the most-significant way to speed up your disks is to use a disk cache and to use it correctly. SMARTDRV supplied with DOS 5 and 6.x and third-party commercial disk caches can speed up disk operations considerably. The advantage of SMARTDRV is that it can share memory with *Windows*, shrinking its cache when *Windows* applications need more memory. Also, the version of SMARTDRV shipped with MS-DOS 6.2 can cache data from CD-ROM drives, as well as floppy and hard disks. Few third-party caching programs have both of these capabilities, but some are better if you're working on a network or if you want every possible bit of speed during disk data transfers.

Disk caches work during disk reads by attempting to predict what data your computer will need next. They also keep data that has already been read, in hopes that the computer will request it again, and they collect data that hasn't been requested yet in case the computer is reading through a file sequentially. The first kind of caching is most effective for reading disk structures like the File Allocation Table (FAT) and subdirectories. The second is effective whenever you load a program, run a batch file or read sequentially through a text or data file.

A disk cache can also speed up the process of writing to a disk by keeping the new information in memory until the computer is idle. In this way, you can get on with your work instead of waiting for a moment for the data to be sent to the disk. The computer seems to be much faster because you can get more work done without pausing. The danger of delayed-write caching, of course, is that you run the risk of losing data if a power failure or computer lock-up occurs while data is waiting in the cache to be written to disk. The worst-case scenario is that a file will be written but that the updated FAT will still be in the cache when your computer goes down.

SMARTDRV and most other disk caches won't lose data if you re-boot your computer by pressing the Ctrl-Al-Del key combination when a cache write is pending because they can intercept these keystrokes. However, they may lose data if you press the hardware RESET switch on your PC or turn off your computer in the short interval while data is held in memory. Whether or not you want to take this risk is up to you. I appreciate the

Ways to Tune Your CONFIG.SYS File

Before you make changes to your CONFIG.SYS file, always make certain to keep a copy of your old CONFIG.SYS file and create a bootable floppy disk. Here are two techniques that should help you improve the performance of your computer.
(1) ***Memory Management.*** If you use MS-DOS 5.0 or 6.x memory managers, include the following lines:

```
DEVICE=HIGHMEM.SYS
```

On 286 and later computers with more than 640K of RAM also include:

```
DEVICE=EMM386.EXE
```

or

```
DEVICE=EMM386.EXE /NOEMS
```

on 386 and later computers with more than 640K of RAM (other options can also help)

```
DOS=HIGH
```

if you've loaded HIMEM.SYS

```
DOS=HIGH,UMB
```

if you've loaded HIMEM.SYS and EMM386.EXE. Change all subsequent

```
DEVICE=
```

statements to

```
DEVICEHIGH=
```

Run MEMMAKER to optimize placement of devices
(2) ***Other Options.*** There are also other things you can do to boost the performance of your computer. Here's a list of some of them:
(1) Set BUFFERS= low if you install a disk cache.
(2) Omit VERiFY= and BREAK= statements; they don't do more than just slow things down.
(3) Set LASTDRIVE= high to enable use of SUBST.
(4) Try FCBS=1 to save memory; if your computer locks up after some use, remove this line to accept the default value of 9,128 (nine stacks of 128 bytes each)

Ways to Tune Your AUTOEXEC.BAT File

Before you make changes to your AUTOEXEC.BAT file, always make certain to keep a copy of your old AUTOEXEC.BAT file and create a bootable floppy disk. You should add your old AUTOEXEC.BAT file to the same bootable floppy disk on which you have your old CONFIG.SYS file. Here are a few things in AUTOEXEC.BAT you can do to improve the performance of your computer.

(1) Shorten the PATH and put small, often-used directories first. Remove all directories from your PATH statement that contain just one or only executable files.

(2) If you're using HIMEM.SYS and EMM386.SYS, install all memory-resident programs with the LOADHIGH or LH command. Then run MEMMAKER to optimize usage of high memory.

(3) Set TEMP= to a directory on your fastest drive, preferably a RAM drive. If you use small batch files to avoid a long PATH statement, put them on the RAM drive as well, along with COMMAND.COM.

(4) Avoid using the "dangerous" DOS utilities: APPEND and ASSIGN. FASTOPEN is dangerous if you use DEFRAG and is almost useless if you use SMARTDRV or DBLSPACE or similar programs.

(5) Use DOSKEY macros instead of batch files when possible.

(6) DOS utilities rarely worth the memory they use include: GRAFTABL.COM, GRAPHICS.COM, MIRROR.COM, MSHERC.COM, PRINT.EXE and VSAFE.EXE.

speed of write caching and have simply learned not to turn off my computer immediately after I write data to a disk. SMARTDRV never waits more than five seconds before writing data to disk.

If you let DOS's SETUP program install SMARTDRV for you, it makes an assumption that it will waste memory and slow down the disk cache on almost all computers. SETUP always installs SMARTDRV with double buffering, which means that the cache uses two buffers: a main one in extended (XMS) memory and a smaller one in conventional memory. Each time data is transferred from the disk, it must pass through the conventional-memory buffer on its way to the extended-memory buffer. It's then transferred back to conventional memory if the data was requested by DOS or a DOS application. Data sent to disk follows the same path, but in the reverse direction.

Double buffering is a necessity only if your hard-disk controller is an older one that doesn't know how to send data to and retrieve data from beyond the 1M boundary. Only a few computers need double buffering. If you use EMM386.EXE (or another EMS emulator on a 386 or later computer) or if you run *Windows* in enhanced mode, you may need double buffering if you have an SCSI hard drive, ESDI hard drive or a Micro Channel computer. However, only some computers that fit this profile need double buffering. To determine if your computer does, perform the following procedure with the version of SMARTDRV included in MS-DOS 6:

Add the line

```
device =c:\dos\smartdrv.exe /double-buffer
```

to your CONFIG.SYS file. Then add the line

```
c:\dos\smartdrv.exe (and any optional parameters)
```

Finally, re-boot your computer and, from the DOS prompt, type SMARTDRV /S and hit Enter.

If after doing the above any entry in the fourth column (Buffering) indicates "yes," you need double buffering. If every entry in this column is "no," you can disable double buffering by removing the device= smartdrv.exe from your CONFIG.SYS file. At the very least, you'll reclaim the space that the second buffer was using in conventional memory.

Once you have a disk cache installed, you're still not up to maximum disk-transfer speed. Before the popularity of disk caches, many users (and many application installation programs) used the BUFFERS= statement in CONFIG.SYS to create a simple disk cache. It was normal to specify 20 to 50 buffers, depending on the size of the hard drive, to speed up system performance. DOS used these buffers to keep frequently-used information in memory and avoid constant rereading of the hard disk. However, when you have a disk cache installed, DOS's disk buffers aren't needed They can slow down your system and waste RAM. With a disk cache, you can decrease the number of buffers to a very low number, such as BUFFERS=2 or 3, because the cache provides the buffers that DOS formerly created by itself.

You can also eliminate FASTOPEN, a DOS utility that keeps track of the locations of frequently-used files and subdirectories, if you're using a disk cache. FASTOPEN is a particularly useless utility and can even slow down your computer if most of your data is on a drive that's compressed with a program like MS-DOS 6.x's DoubleSpace or *Stacker*.

Speed Up *Windows*

Users either love or hate *Windows*. Those in the latter group often complain of *Windows'* slow operations and how it even bogs down DOS programs that are run from within *Windows*. Often, their complaints are based on a *Windows* installation that runs at less-than-optimum speed and is also in need of a tune-up.

The first requirement of *Windows* is to have enough physical and virtual RAM in your system. To use *Windows* satisfactorily at all, you should have at least 4M of RAM. Upgrade to 8M if you plan to have two or more major *Windows* applications open simultaneously. Also, unless your hard disk is very cramped for space, create a large permanent swap file. The permanent swap file must be on a partition of your hard disk that isn't compressed. *Never* try to manipulate a permanent swap file directly from DOS. Instead, open the *Windows* Control Panel, select the 386 Enhanced icon and select the Virtual Memory button. Temporary *Windows* swap files are slower than permanent ones because of the way *Windows* accesses them. *Windows* always uses standard DOS read and write commands to use a temporary swap file. However, it assumes that it "owns" the space in a permanent swap file and reads from and writes to it directly. Because of the way *Windows* uses them, permanent swap files require the use of contiguous disk space. Therefore, run a defragmenting utility from DOS before you install a permanent swap file in *Windows*.

A second way to speed up *Windows*

is to avoid background DOS sessions, unless they're absolutely needed. A background DOS program receives time from the CPU, whether or not it has the keyboard and mouse focus. *Windows* applications always run in the background, but they're written to give up their CPU time unless they have some work to do. Most DOS applications aren't so considerate.

You can select whether a DOS application or session runs in the background when you create its PIF, or Program Information File. If you leave blank the Background check box, the application receives processor time only when it has the focus. (The related check box, labeled Exclusive, tells *Windows* to suspend other programs, even those marked Background, when the "exclusive" DOS program is running.)

You can change a program's Background and Exclusive settings while it's running by selecting its control button (if it's running in a window) or by pressing Alt-Space Bar. From the control menu, choose Settings. You can then turn on or off either option. If you want a DOS word processor to print in the background while you do other work, leave its Background option unchecked until you're ready to print.

If you run DOS applications without PIF files, load the file titled _DEFAULT.PIF into the PIF editor and make sure that it has both boxes unchecked. The _DEFAULT.PIF file is used to establish settings for any DOS program that doesn't have its own PIF file of settings.

Although the PIF editor has excellent help for each option, the process of tuning a PIF file is baffling to many users. One way to dramatically speed up DOS applications in enhanced mode is to make sure that all three Monitor Ports options are unchecked in the PIF file, unless you're using an EGA video adapter. When these options are on, *Windows* must watch constantly to see if the program has done anything on the screen that *Windows* won't be able to undo when you switch to a different application. These options are hardly ever needed.

If DOS applications appear to run slowly inside *Windows* when they're writing to the disk, look at your SYSTEM.INI file with a text editor like Notepad or with the SYSEDIT.EXE utility supplied with *Windows*. In the [386Enh] section of SYSTEM.INI, you should find this line:

```
FileSysChange=Off
```

If this line is missing or if you see FileSysChange=On, *Windows* is snooping during every disk write to see if your DOS program has changed the entries in any subdirectories. *Windows* then sends this information to File Manager or any other *Windows* application that has asked for it. Since every disk write changes the length, time stamp or name of a file or creates or deletes a file, each one causes a pause while every "interested" *Windows* program records the change.

When you set FileSysChange=Off, none of this extra activity occurs. File Manager's display won't be updated when you return to it, but you can always force File Manager to reread a directory by pressing F5.

Windows applications sometimes seem to be slow, especially if they use multiple fonts. They're being slowed down by a font scaler, a program that reads shape information from a file and forms the screen representation of each character as it's being displayed. The *TrueType* engine in *Windows* 3.1 is one such program. Another popular font scaler is Adobe Systems' *Adobe Type Manager for Windows*.

One way to speed up scaled fonts is to pre-load the ones you normally use. Create a document with your favorite *Windows* word processor that contains the letters A through Z in both upper- and lower-case characters, along with numerals and punctuation marks. Then repeat the text in every font and type size you normally use. You can either load this document each time you run your word processor or have *Windows* run your word processor and load the document automatically every time it starts. Both techniques load the fonts into *Windows*' memory and obviate the delays caused by the font scaler figuring out how to display each new character shape when you type it.

To load the file automatically every time *Windows* starts, first use the File Association command in File Manager to associate the file's extension with your word processor. Then list the file in the LOAD= line near the beginning of WIN.INI. For example, once you've associated .DOC files with *Word for Windows*, you can include the file C:\DOS\ LOADFNTS.DOC as one of the programs that *Windows* should load each time it begins.

Finally, one of the features of *Windows* 3.1 I appreciate most when I'm tuning a system is the StartUp group in the Program Manager. First decide which *Windows* and DOS applications you want to have available every time you start *Windows*. Click once on each icon and then use the File menu's Copy command to copy it to the StartUp group window. If you want each program to appear minimized, as I do, click once in the Start

(Continued on page 107)

Some Ways to Tune *Windows*

Be sure to save a copy of WIN.INI and SYSTEM.INI before you make any changes. You might want to put them on the same bootable disk on which you have your old AUTOEXEC.BAT and CONFIG.SYS files to keep everything in one place. You may want to save a copy of PROGMAN.INI and all *.GRP files in your WINDOWS directory if you're rearranging Program Manager. Here are some tips to wring maximum performance out of *Windows*.

(1) Make sure that SHARE is loaded in your AUTOEXEC.BAT file.

(2) If you want to avoid seeing the Microsoft logo, start *Windows* 3.1 with the command WIN : (WIN <space><colon>).

(3) In the [386Enh] section of SYSTEM.INI, set FileSysChange=Off.

(4) In PIF files, set Monitor Settings to Off and Detect Idle Time to On. Turn off Background and Exclusive when possible.

(5) Most applications and DOS programs will run faster in full-screen mode than in windowed mode because *Windows* has less work to do if it can dedicate the entire screen to one application.

(6) If *Windows* reports that there aren't enough file handles for a DOS application, add PerVMFiles=15 to the [386Enh] section of SYSTEM.INI. If the error occurs again, increase the number to 20 or more.

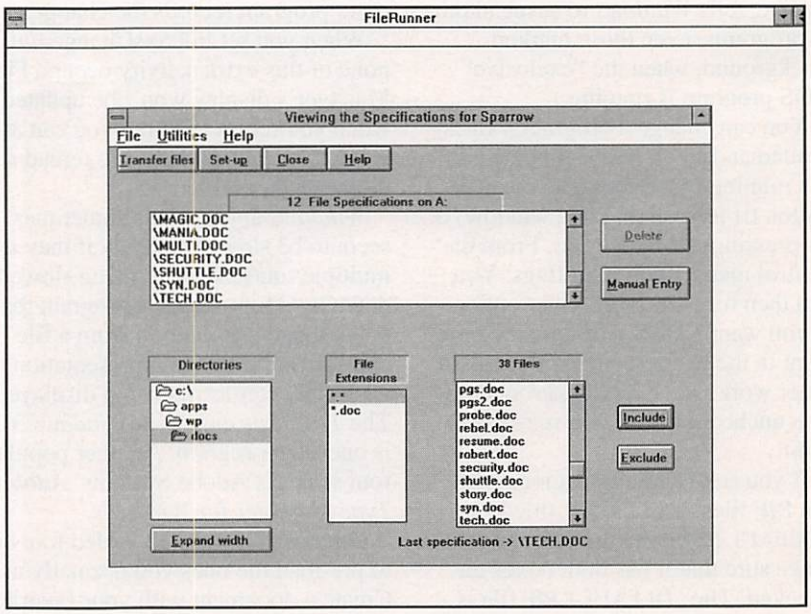
(7) Turn on 32-bit disk access (Control Panel, 386 Enhanced icon, Virtual Memory screen). If your computer is one of the very few that can's run this way, it will lock up. When you re-boot, edit SYSTEM-.INI before you enter *Windows*. In the [386 Enh] section, change 32BitDiskAccess = On to 32BitDiskAccess=Off.

By SF Sparrow

Utilities, Home Design & Multimedia Presentations

Products to help you protect data, write your own professional-style manuals, design the house of your dreams and create your own multimedia presentations

Computer programs are usually grouped into two categories: applications and utilities. When we think of applications, such things as word processors, spreadsheets and database programs come to mind. We think of utilities as disk-cache programs, disk editors and the like. Some programs fit into the gray area between these categories because they're small and efficient enough to be a utility, but expansive enough to be an application. In this article, I'll give you the lowdown on a pair of "now-why-didn't-they-think-of-that-before-now" utilities you'll find useful in your day-to-day computing, tell you about a software package that lets you design your own dream home in 2D and 3D formats and let you in on the ground floor of an easy-to-learn-and use package for creating multimedia presentations



FileRunner prepares to run files over to drive A:.

Protecting Important Data

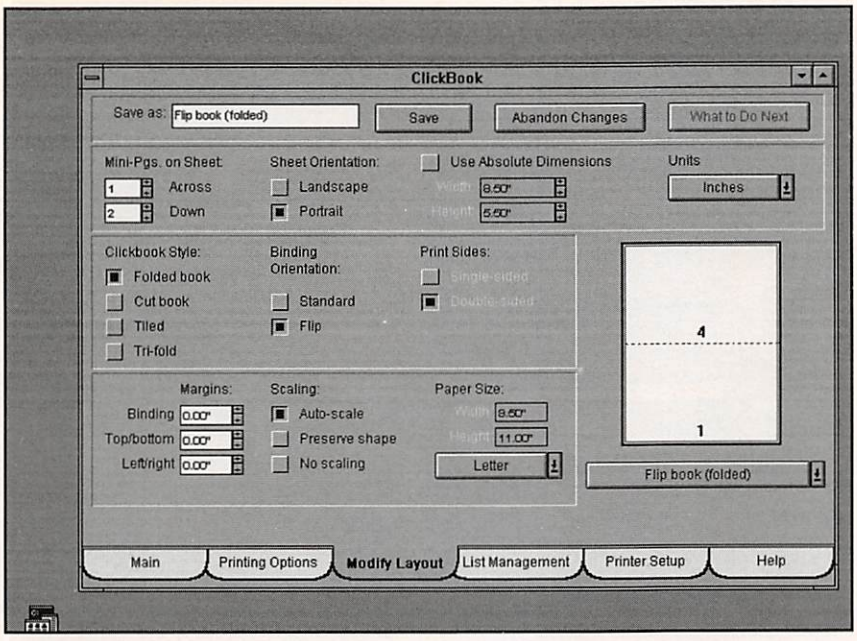
Anyone who deals with more than one computer probably knows the problem of keeping files properly synchronized. Perhaps you're at the office and haven't gotten onto a network yet. If so, you and your co-workers are forced to share the same data, such as a list of names and addresses or critical spreadsheet data. So you copy the data to a floppy diskette and pass it around. Even though you're careful, you know that one day your newer information is going to get copied over by older data.

If you're a PC user at home, you know only too well how to do the floppy shuffle. You're working on the family computer when your children decide that they want to finish playing a hot computer game that has them stumped. Being a kindly parent, you copy your data to floppy disk and transfer operations to your laptop computer. Later, when the kids have gone on to other matters, you return to your desktop computer and start working where you left off. After a couple of entries, you realize that you now have new data in two different locations and that it's not the same in either.

These examples illustrate the potential problems of sharing critical data among computer systems. Eventually, something new gets replaced by something old, no matter how careful you are. The solution to the problem of file synchronization is *FileRunner*, utility-styled-application software from MBS Technologies, Inc.

FileRunner is a simple, one-disk solution that runs under Microsoft *Windows* 3.1. You install it on a computer and that particular copy is electronically assigned to the computer on which it's installed. Then you tell the program which floppy drive is going to be used as your Runner floppy. Finally, you tell the utility which files to keep synchronized. *FileRunner* does the rest. It reads the date and time stamps on your selected files and lets you know when you're attempting to overwrite the new with the old.

FileRunner's user interface is easy enough to figure out without having to read the manual. You can have as



ClickBook lets you print your documents like you want them to be.

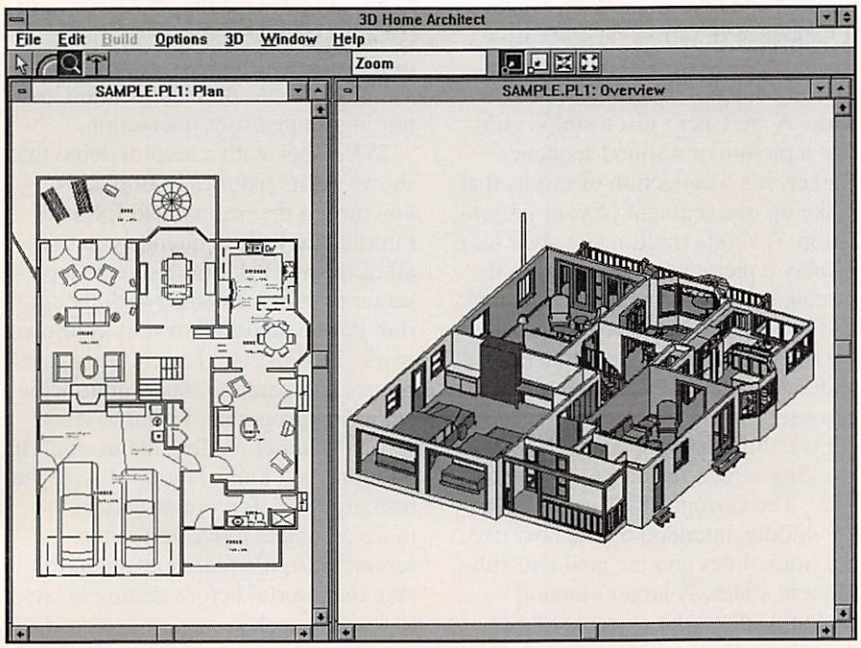
many Runner floppies as you like and *FileRunner* will manage them, prevent accidental overwrites and check your diskettes for viruses. The only thing you have to do is always make sure that dates and times on all your managed computers are the same. File synchronization software comes in running flavors for *Windows* and DOS on the PC and for the Mac. It makes allowances for time zones and daylight savings time. *FileRunner* is a clean, efficient solution to a nagging problem. It's surprising that this little jewel took so long to show up.

Creating Your Own Books and Manuals

Another nifty utility-gone-application is *ClickBook*. All this one does is print documents in various sizes, but it does it double-sided, portrait and landscape. It also places marks on the printed documents so that they can be folded and stapled into a book style of your choice.

You may not think about it that much, but wouldn't it be nice to print out a little book of phone numbers and addresses into a pocket-sized document? *ClickBook* comes with a host of ready sizes from which you can choose. If you don't like any of these supplied layouts, you can design your own in just a few minutes. Then you can preview it, see what it's going to look like and fine-tune it if necessary. As an example, *ClickBook* turns a typical 24-page word-processed document into an easily handled six-page booklet-size pamphlet.

Scaling and paging are automatically handled by the *ClickBook* program. To print your own personal folding books, you'll need *Windows* 3.1 and a laser printer. Like *FileRunner*, one wonders why this excellent utilitarian idea didn't hit the marketplace much earlier than now.



2D and 3D views of a simple dream home from 3D *Home Arhitect.*

Designing Your Dream House

Part of the American dream is having a nice family and nesting it in a nice house. Making the dream more appealing is the possibility of having a hand in the design of your own house, as is offered by many home builders. Designing a house requires a high degree of architectural expertise. Few of us can properly design a house. That's why computer software like Broderbund's *3D Home Architect* exists.

3D Home Architect is a do-it-yourself home-design/remodeling program that runs under *Windows*. Its purpose is to allow anyone to create complex architectural designs. A tool that facilitates ease of use is the *Windows* operating environment and the fact that the program keeps menus to a minimum. Even though *3D Home Architect* is quite sophisticated, it doesn't take an all-day tutorial to start producing meaningful house plans. If you don't feel like designing a new plan for scratch, you can choose from more than 50 existing plans. Call them up and modify them according to your likes.

A very useful feature in *3D Home Architect* is the one that keeps you

from putting parts in the wrong places. The program won't let you put a door, window or fireplace where it doesn't belong. Preventing such amateur errors up front saves time later. Another time-saving feature is that the program keeps track of materials and prepares a spreadsheet that you can use to calculate expenses. When you finish drawing your dream house, you can take an electronic tour of your work and make last-minute changes along the way.

Yet another useful feature of *3D Home Architect* is its dual 2D and 3D working mode—2D mode gives you a catwalk view of your design with detailed measurements, while 3D mode offers a more life-like look at your house but still permits interactive editing. It takes longer for the computer to draw the initial 3D image, but subsequent re-draws are much faster.

In 3D mode, you pan and zoom to look at your design from just about any angle. After sizing everything, you can export your design to various CAD and .DXF file formats and hand the disk to your builder. This doesn't mean your builder will take your design and run with it, of course, but at least your builder will know that you're not just another dumb consumer chasing the American dream.

Multimedia Made Easy

Multimedia has dashed into the personal-computer world quickly and irrevocably. CD-ROM and CD players appear in more and more businesses and households every day. The once-disparate technologies of video, sound and computers merge ever closer to become a single, multi-faceted entity. A key ingredient that can tie them all together is multimedia software.

SST is a software product that allows anyone who has basic computer skills to create a multimedia presentation in a comparatively short period of time. *SST* stands for *Super Show & Tell*. It's published by Ask Me Multimedia. The product's aim is to slash effort and cut time for multimedia presentations. In this, it's quite effective.

SST's secret to quick and functional multimedia is really no secret. It's design displays evidence of forethought and concern for simplicity. If you've ever set out to use one of the many

Super Show & Tell teaches multimedia.

multimedia authoring products, you've probably spent more hours than you realized—or wanted, really—on learning how the software works and becoming acceptably skilled at operating it, only to come away with a meager presentation that doesn't reflect your efforts. *SST* isn't so difficult to deal with.

SST bases its operating concept on a very familiar pre-existing multimedia technique: the slide carousel. Most of us have sat through slide presentations of one kind of another, whether it happened in school, at work or at home. With *SST*, each part of your multimedia presentation is called a slide. A slide isn't just a single item, like a picture or a sound sequence. Rather, it's a collection of events that make up one segment of your presentation. A single multimedia slide may display a picture, move text onto the screen, invoke a synchronized sound and play a video clip. Even though it may do all of this, it's still only one slide in a potentially large multimedia carousel.

Five slides are displayed on your working screen for purposes of reference. The current slide is always in the middle, bounded by the next two previous slides and the next two subsequent slides. A larger viewing screen displays the current slide so that you can see what you're doing. A simple mouse-click on any other slide brings that one into primary spot and into the viewing area. Already, you get an idea of the streamlined simplicity of *SST*.

The heart of any multimedia software is motion and sound. *SST* reads them all as objects of one kind or another that can go on any slide. The objects, in turn, have attributes that you can use to change the associated object. For example, text objects have a font style, but graphic objects don't. Objects also have action elements so that you can make the object move or change size and color. A special action element allows your presentation to jump to a pre-defined location, permitting limited user interaction.

SST comes with a helpful demo that shows off its features. Afterwards, you turn to the manual and follow a tutorial that fully acquaints you with all of the needed tools to create a presentation. Once finished with the tutorial, you're qualified to start your own work. To illustrate the product's ease of use, compared to other multimedia authoring programs, I went to work on *SST* without reading the manual. In 30 minutes, I knew how to change the background color, create text and make an object move across the screen. Still, it's more expedient to take the tutorial before getting down to serious work.

SST can help you pull together a rather wide range of data formats into

(Continued on page 112)

By Robert Davis

"Greening" Your PC's Video Monitor

For years, I've hung up signs emblazoned with the message "Turn off monitor when not in use" to no avail. The widespread use of screen savers that do little more than entertain computer users. Something needed to be done. So I developed a simple electronic device that can be used to turn off a PC's video monitor when no keyboard has been detected for a preset period of time. It's my own idea of an energy-saving "green" monitor without the expense of having to replace your present monitor.

The circuitry for my "greening" device is shown in the schematic diagram. The 556 timer chip operates as two single-shot multivibrators. The first acts as a pulse stretcher that, via the 2N2222 transistor connected to pins 12 and 13 of the IC, discharges the 470-µF electrolytic capacitor of the second multivibrator. Both multivibrators trigger the instant any key is pressed on the PC's keyboard. With the component values shown in the schematic, the first multivibrator won't time out until no keyboard activity is detected for a period of 10 minutes.

When the circuit does time out, it triggers the 12-volt dc relay via the second 2N2222 transistor, interrupting one of the 120-volt ac lines from the wall outlet to the socket into which your PC's video monitor is plugged. Once this occurs, simply pressing any key on your keyboard triggers the circuit to again close the relay's contacts and ac reapply power to the socket. The reset signal for the greening device comes from the DATA line of your PC's keyboard cable and connects to pins 6 and 8 of the 556 timer chip. You can change the timing period, simply by changing the value of the 470-µF capacitor. For example, substituting a 1,000-µF capacitor stretches time-out period to 20 minutes.

Since power requirements for the greening device are modest, you can use just about any plug-in wall-type 12-volt dc supply or a 12.6-volt transformer/ bridge rectifier/470-µF filter-capacitor arrangement.

The relay I use in my prototypes comes from Radio Shack and can safely handle up to 10 amperes of current. This is more than adequate for even the most power-hungry video monitor.

Construction of the project is as simple as its design, though it does require a bit of machining. You can assemble the circuitry on perforated board that has holes on 0.1" centers, using Wire Wrap or/and soldering hardware.

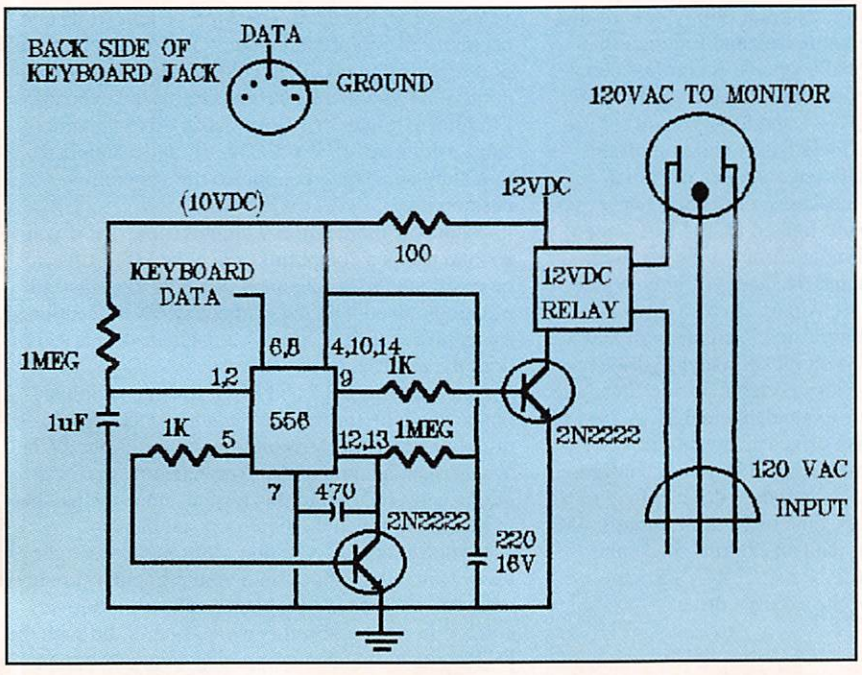
Everything except the relay, ac receptacle into which you plug your video monitor's power cord, keyboard jack and the line cord that goes to the ac outlet mounts directly on the board. When wiring the circuit, observe proper polarity when connecting the capacitors (the flat plate identifies the + lead), basing for the two transistors and orientation for the IC.

Use any plastic or metal utility box that measures at least 6" X 3" X 2" to house your greening device. You use a chassis-mount ac receptacle or a line-cord socket. Whichever you choose, machine the enclosure accordingly. Be sure to use a three-conductor ac power cord and grounded (three-contact) receptacle or socket. Similarly, you can hard-wire the power supply directly to the circuit assembly or route it into the enclosure through a jack-and-plug arrangement.

Don't attempt to directly wire to the existing connector at the end of your keyboard's cable or to the keyboard socket mounted on your PC's motherboard. Instead, obtain a keyboard cable and a standard chassis-mount keyboard connector like the one on your PC's motherboard. You can salvage the cable from an old keyboard and purchase a chassis-mount connector to effect the required connections.

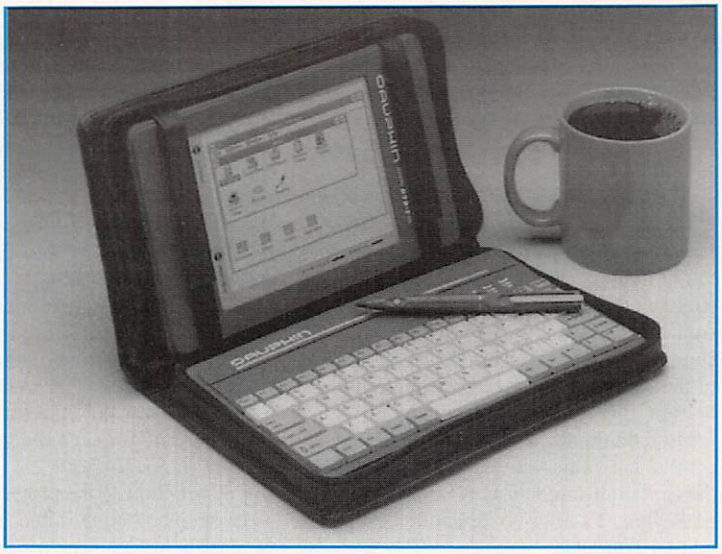
Mount the keyboard socket connector on one wall of the enclosure in a suitable-size hole and secure it in place with hardware through its mounting "ears." Then route the free end of the keyboard cable through a hole in the enclosure and connect and solder the cable's conductors to the pins on the socket connector in the same sequence as on the connector at the other end of this cable (pin-1 conductor to pin 1 of the socket, pin-2 conductor to socket pin 1, and so on). Referring to the pinout diagram at the top of the schematic diagram, connect and solder a hookup wire between the DATA (center) pin of the socket and pins 6 and 8 of the 556 timer chip. Connect and solder another length of wire from the GROUND pin of the socket to circuit ground on the project's circuitboard assembly.

Plug the keyboard cable on the project into the keyboard socket on your PC's motherboard and your keyboard into the socket on your greening device. Then plug your video monitor into the ac receptacle or socket and the ac line cord on the project into an ac-line receptacle. Leave the power switch on your monitor permanently turned on. ■



A Unique Hybrid Computer: Dauphin's Desktop Replacement Model

By Art Salsberg



The Dauphin DTR-1 is an intriguing computer. Like integrated software, it combines multiple functions, in this case, subnotebook computer, pen computer and desktop computer. All this in a 2½-lb. compact package. The challenge here is how well does it perform in each format? Is it really a computer for all seasons? The portable 25-MHz 486-microprocessor-based machine comes with a built-in hard-disk drive, 9,600/2,400-baud data/fax modem and a detachable miniature keyboard that has the same footprint as the machine's "system unit." Preinstalled software includes DOS 6.0, *Windows* 3.1 and *Windows for Pen Computing*. Other supplied software features a reduced version of PenWare's *PenCell Spreadsheet*, Microsoft *Notebook*, advanced power management and a bevy of utilities.

The machine features a variety of ports: parallel, serial, external monitor, external floppy or hard-disk drive, keyboard, telephone jack and Ethernet (the last requires an optional adapter). A cordless computer pen, an ac/dc power adapter and a soft portfolio case to hold the DTR-1 and its keyboard for use as a subnotebook are included. A slide-on plastic cover protects the LCD screen/tablet and ports.

The basic DTR-1 measures a compact 9½" x 5-1/2" x 1¼". The back-lighted LCD VGA screen provides 6" diagonal monochrome viewing, with 640 x 480 resolution and 64 shades of gray. Video memory is 1M. The VGA port can also drive a super-VGA color monitor in 256 colors with 800 x 600 resolution. A 7.2-volt nickel-metal-hydride replaceable battery provides portable power. Standard RAM is 4 M, which is expandable to 6 M. A 20M or 40M internal hard-disk drive can be chosen.

The DTR-1 system examined here was configured with a 40M Hewlett Packard hard drive, which recorded an average seek time of 17 milliseconds, 4M of user RAM memory and an external 3½" mini-disk drive measuring 5½" x 4½" x ¾". Price is $2,500, plus $200 for the external drive.

In Use

The DTR-1's 25-MHz Cyrix 486 microprocessor and Oak Tech BIOS (dated 4/19/90) were up to par in all tests. With this arrangement, it took one minute to load *Windows* and DOS. The real question is: "How does the DTR-1 fare as a desktop, subnotebook and pen computer?"

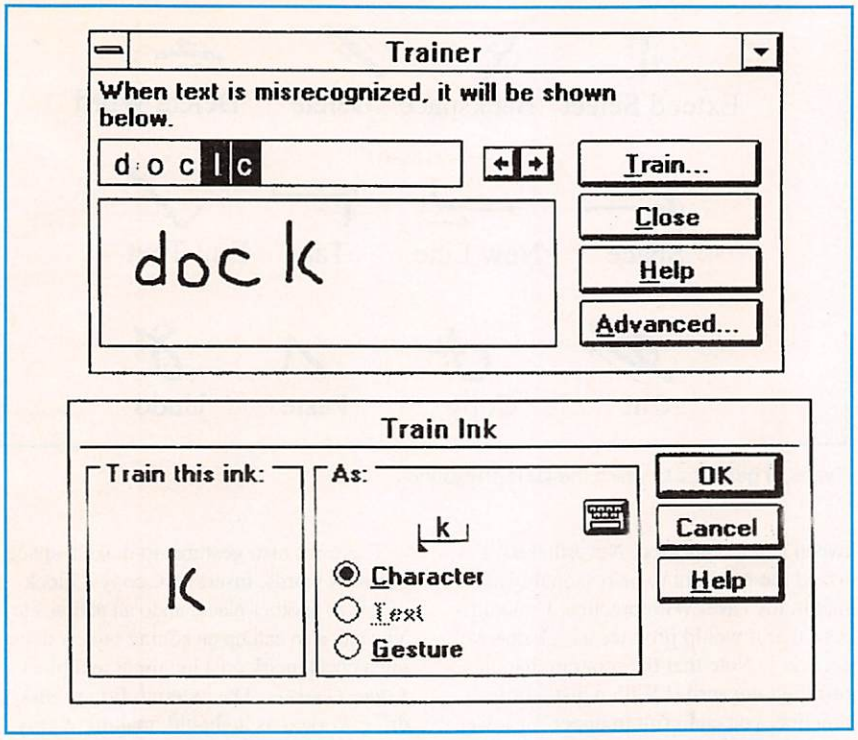
• ***Desktop Use.*** Set up as a desktop system while connecting a 14" color video monitor to the appropriate port revealed an excellent color display during operation. Plugging in a Keytronics full-size keyboard, a Dauphin external 3½" floppy-disk drive that measures a compact 4½" x 5½" x ¾" and a supplied miniature ac adapter completed the system for desktop use.

Naturally, this setup is a cumbersome one if you wish to use pen computing, since the DTR-1 has to be positioned for convenient pen operation instead of being moved a bit out of the way. Even positioned aside, however, it occupies valuable desk space, as does the external floppy drive.

Both screens, CRT and LCD, operate simultaneously when the former uses standard VGA resolution. For super-VGA resolution, however, the LCD screen must be turned off. Consequently, pen computing can't be used in this format, since the pen has to be used to touch the liquid-crystal display.

If you're like me, you don't thoroughly read the user manual that comes with your computer products until you encounter a problem you can't intuitively correct. In most cases, this works fine. It did with the DTR-1, including pen-computing elements but excepting special gestures.

For heavy-duty desktop work, the miniature keyboard isn't adequate to the task. To begin with, the



DTR-1's Trainer and Train Ink screen captures.

keys are spaced more tightly than they are in a standard keyboard's layout. Moreover, some keys are located in unfamiliar areas. And an additional key, the Dauphin key, must be pressed to give user access to various keys labeled with green legends. One can get used to all this, of course, but it will slow up a good typist. Furthermore, the keys operate too stiffly.

So for efficient desktop typing, a standard-size keyboard substitute is highly desirable. But they're inexpensive and simply require plugging a PS/2-connector-equipped external keyboard into the keyboard port at the back of the DTR-1.

Pen computing in a desktop setup can be awkward because you must use the pen on the LCD screen while observing its position and movements on the large color monitor attached to the computer. Of course, you can ignore the color screen and view everything on the LCD tablet, but, then, you're really not in a desktop environment with the viewing advantages of a large color screen. With a little experience, it's easy to do, but it's certainly not physically ideal.

The DTR-1 has other limitations as one's sole desktop computer as well, since it lacks expansion slots, has limited memory and internal hard-disk capacity for really heavy-duty programs. Nor does it contain PCMCIA slots. It can, however, run on a network, with addition of an internal Ethernet adapter.

• ***Subnotebook Use.*** The leather portfolio case included with the DTR-1 uses Velcro straps to secure the DTR-1 in the upper half of the case and a Velcro strip that catches the bottom of the miniature-keyboard in the lower half. A support easel can be adjusted to tilt the LCD screen to a comfortable viewing angle and pen-touch position. A computer pen holder for storage purposes is also incorporated in the inside spine area of the case.

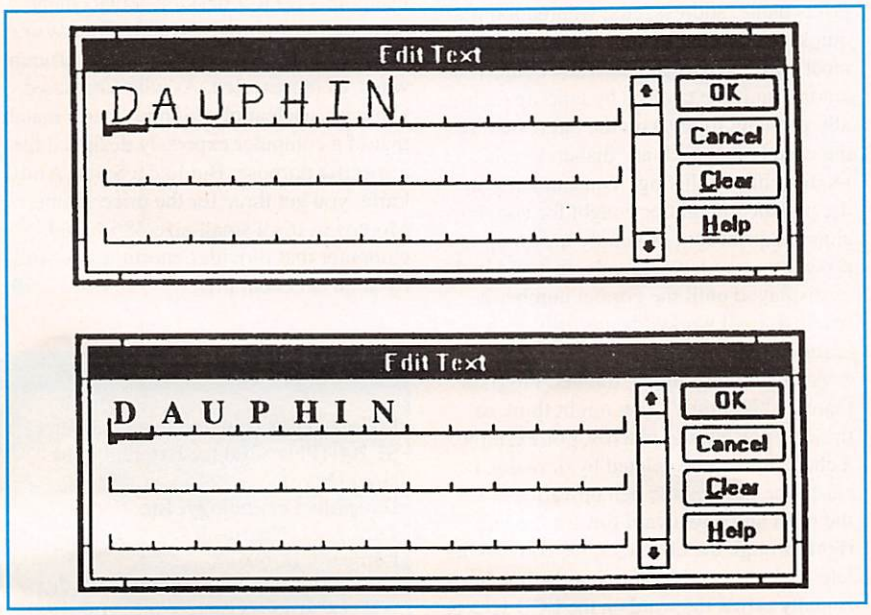
The miniature keyboard has an L-shaped connector that plugs into the keyboard port. If you use the video monitor port next to it, you have to use a straight-line connector that's provided, since the bend in the miniature-keyboard connector blocks the video connector.

The subnotebook computer system works fine, although its physical setup isn't as good as that of typical subnotebook models that have a flip-type LCD lid and better keyboard.

As a portable, the internal battery is said to require recharging after about 2½ hours of use, which isn't as long a time as most notebook computers provide. Also, when the time comes that the battery can no longer hold a charge and you have to change it, you'll lose whatever data you have in memory. Therefore, work must be backed up before changing a battery. An optional battery pack cover will be available to extend battery use to eight hours.

• ***Pen Computer Use.*** Turning to the third face of the DTR-1, that of a portable pen computer, eliminates all cables hanging from its ports, as well as its peripherals. Now you have a neat tablet-face machine that's on the heavy side and kind of large. It's not a PDA (personal digital assistant) or even a palm-held type of pen computer. But placing it on a desktop or laptop, rather than walking around with it at the ready, it fills the bill very nicely.

The pen itself runs on three tiny battery



Editing Box shows handwritten (upper) and computer's replacement (lower) with formed type.

cells. If the pen is inactive for three minutes, it shuts itself down, conserving power. Tapping the pen tip activates it again.

Viewing the DTR-1's LCD screen in a landscape format, four legends line the right side: Brightness, Contrast, Sus/Res (for suspend/restore) and Turbo. The wireless pen is used to control these functions. Tapping a left- or right-hand arrow on either side of Brightness and Contrast activates these controls. Tapping next to Sus/Res either shuts down almost everything excluding memory and restores operation. Tapping Turbo will either cause the computer to run at 25 MHz, which is signaled by two beep sounds, or 8 MHz, which is signaled by one beep. At the other end of the computer are indicator lights for power on, hard-drive use and low battery power.

There's no place on the computer itself to store the pen, so you have to carry it somewhere else.

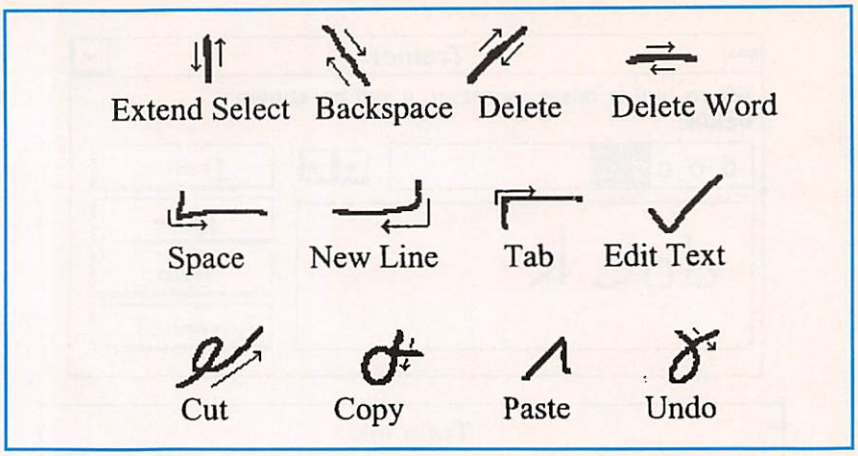
For Pen computing, Microsoft *Pen Computing for Windows*, which includes Microsoft *Notebook* in its Pen Group, is started. The display looks like a *Windows* 3.1 screen and is quite easy to use by light touches of the pen, which has a retractable tip. A variety of menus and a number of icons are activated by a light tap, either by one tap or two taps.

In case you need a keyboard for very limited work, you can also summon one for on-screen display. Tapping keys with the pen can input a character or another type of input.

A Pen Palette runs in the background and can be called up by double-tapping its icon. Here, you can edit, cut, copy, etc. In addition, various options can be selected, such as enabling handwriting recognition, choosing letter guides, reducing or enlarging the Pen Palette, a handwriting Trainer window and a Help menu, among others. There's also a utility for a DOS mouse driver that permits the pen to function as a mouse in most DOS programs. The pen has side buttons that simulate a mouse's right button, while the pen tip acts as the left mouse button.

I found the handwriting recognition program to be excellent. Others who don't print very neatly, as I do, will have some difficulties and have to train the program to recognize their letters and numbers.

If I printed without lifting up the pen from the surface, I usually hit the character on the head. A print font of what's done by electronic ink quickly pops up if it's recognized. If not, a question mark appears, alerting you to try again. Once in a great while a mistaken character recognition was made or an unwanted space between letters appeared. Nevertheless, I found the program to be reasonably accurate in my case. With practice, I'm confident that it would produce a high order of accuracy. Note that the program handles printing, *not* script! With a just a little practice, you can print in upper- or lowercase letters, too.



Types of gestures to which the DTR-1 responds.

With Microsoft *Note*, you can write, scribble and draw, just as you can with a ball-point ink pen. You can also print and have the results converted into typewritten text, draw a rough circle and have it converted into a perfect circle, choose line widths. Additionally, you can bring up a notebook calendar and a table of contents.

A few representative forms are included in the pen programs, such as a Health Form. Here's where the pen function really shines for someone who can't type or doesn't have a keyboard handy. The user prints name, address, etc., whereupon it's quickly converted to a print font. For the most part, the user makes a selection from among multiple choices by tapping (actually pressing lightly) on the circle next to the correct fact such as "diabetes" in a medical history listing. You can write in the patient's height or weight for conversion to a print font or simply tap an up or down arrow to have pounds, feet and inches displayed until the correct number is reached. It all worked beautifully with hardly a redo needed!

As mentioned above, the Pen Program features "gestures." You might think of these as pen editing macros. For example, a character can be deleted by drawing a slash line moving the pen upward toward the right and downward toward the left, right through the character. Or you can delete a whole word by moving the pen horizontally across the word on the LCD screen, and then backward from right to left.

There are also gestures to make a space between words, insert text, copy a block of text to another place, undo an action, etc. You can also call up an editing box by drawing a check mark on a highlight text block.

• ***Other Functions.*** The external floppy-disk drive worked as it should, making it easy to load new programs. The internal fax/modem transmits and receives Fax Class 1 messages (9,600 baud), while the modem operates similarly up to 2,400 baud. The Dauphin unit doesn't come with a communications program. Though the LCD display/tablet, which measures 3" x 5", is on the small size, it's display itself is clear and sharp. You can set the display/tablet to landscape or portrait mode, making it possible to handle most forms nicely.

Conclusions

Dauphin's DTR-1 desktop-replacement computer is an impressive modular system that can, indeed, perform in three different ways, as represented. As with integrated software, each application use can't match that of a computer expressly designed for a specific purpose. But like a Swiss Army knife, you get three for the price of one. Moreover, it's a small-size 486-based computer that provides enormous versatility at an excellent price. ■

Product Tested

DTR-1 Pen-Based Portable Computer, $1,200 (Plus $200 for External 40M Hard Drive)
Dauphin Technology, Inc.
1125 E. St. Charles Rd.
Lombard, IL 60148
Tel.: 708-627-4004; fax: 708-627-7618
CIRCLE NO. 130 ON FREE INFORMATION CARD

By John Hastings*

Industry Watch

Following Microsoft's introduction of *Windows* 3.0, some people have said that *Windows* makes IBM an abbreviation for "I Became a Macintosh." When Microsoft releases *Windows* 4.0 sometime later this year, the moniker will be well-deserved. It will be a true 32-bit operating system. This will permit filenames to be more than eight characters in length. The "plug-and-play" capability will permit devices to be attached and removed without endless reconfiguration of software drivers, switches and jumpers.

While the Macintosh has had most of the features of *Windows* 4.0 for many years, Apple is working diligently to add new features to stay ahead of Microsoft. *AppleScript* has recently been released. This scripting language allows a user to link together several applications to act as one. While the Macintosh operating system has always had built-in networking software, Apple recently added an electronic-mail function as well. The company hopes that these new features—as well as voice recognition, voice synthesis and video support—will keep it a step ahead of *Windows*.

Though many of us have spent hours debating the pros and cons of the North American Free Trade Agreement, one group certain to benefit from its passage is computer users. Used-computer prices should fall more gracefully and, in some cases, even rise due to NAFTA. A 20% tariff has made export of our older computers to Mexico economically unfeasible. Without this tariff, millions of PCs, XTs and 80286-based computers will be headed south of the border. Mexico has other free-trade agreements currently in place with several Central and South American countries. This will allow many of these computers to continue their southern migration.

Prices are falling on most new computers that use Intel's most-powerful CPU chip, the Pentium. This may be due in part to the disappointment in the performance of the new chips. The average computer user won't notice a speed improvement until it's at least 100% faster than his present system. Most computer users have

Prices of Used Computer Equipment for December 29, 1993

Machine	Average Buyer's Bid	Average Seller's Ask	Close	Change
IBM PS/2 Model 30/286, 20M	$300	$525	$375	+$50
IBM PS/2 Model 50Z, 30M	300	650	350	**
IBM PS/2 Model 70,120M	600	900	650	+50
IBM PS/2 Model 80,70M	450	850	550	–25
IBM ThinkPad300	1,250	1,650	1,200	**
IBM ThinkPad700	1,600	2,200	1,925	–25
AST 286/12, 40M	275	675	300	–25
AST 386/20, 80M	550	850	625	**
Dell 325SX, 50M	400	800	525	–50
Dell 386/20, 120M	600	1,000	675	+25
Gateway 286/16, 40M	250	550	300	–25
Gateway 386SX/20, 80M	500	950	600	–25
Gateway 386/25, 80M	600	1,000	700	**
Clone AT 40M	250	550	325	**
Clone Notebook 286, 40M	350	750	550	+50
Clone Notebook 386SX, 40M	500	950	750	+50
Clone 386/SX 40M, VGA	450	950	525	–75
Clone 386/25 80M, VGA	450	950	625	–25
Clone 386/33 80M, VGA	550	1,050	725	–25
Clone 486/25 120M, VGA	800	1,450	950	+50
Compaq SLT/286 20M	250	500	350	**
Compaq LTE 286 40M	400	775	525	+25
Compaq Portable III, 40M	250	650	275	**
Compaq Deskpro 286, 40M	250	650	275	–25
Compaq Deskpro386/20e, 100M	600	900	600	–100
Macintosh SE, 20M	300	650	400	**
Macintosh SE/30, 40M	375	800	500	–50
Macintosh II, 40M	400	750	550	–50
Macintosh IIcx, 80M	500	900	600	–125
Macintosh IIci, 80M	900	1,100	925	–75
PowerBook 100 4/20	525	900	600	–100
PowerBook 140 4/40	900	1,400	1,000	**
PowerBook 170 4/40	1,100	1,700	1,500	+25
LaserWriter IINT	700	1,000	800	+50
Toshiba 1200XE	300	650	450	+100
Toshiba 1600	300	600	350	+50
Toshiba 2200 SX, 60M	600	1,100	825	–50
Toshiba T-3100SX, 100M	500	900	675	+75
Toshiba 5200, 100M	850	1,250	1,000	–50
HP LaserJet II	400	850	600	–25
HP LaserJet IIP	325	950	475	**
HP LaserJet III	600	1,000	875	–25

*John Hastings is the president of the American Computer Exchange Corp., which matches buyers and sellers of used microcomputer equipment. For more information contact the American Computer Exchange Corp. at 800-786-0717.

Prices of Used Computer Equipment For January 28,1994

Machine	Average Buyer's Bid	Average Seller's Ask	Close	Change
IBM PS/2 Model 30/286, 20M	$300	$525	$325	–$50
IBM PS/2 Model 70, 60M	450	900	550	–100
IBM ThinkPad 300	1,250	1,650	1,075	–125
IBM ThinkPad 700	1,500	2,000	1,700	–225
IBM ThinkPad 720	1,800	2,500	2,150	–100
AST 386/20, 80M	550	850	550	–75
Dell 325SX, 60M	400	800	525	—
Dell 386/20, 120M	600	1,000	675	—
Gateway 386SX/20, 80M	500	950	600	+25
Gateway 386/25, 80M	500	800	600	–100
Gateway 486/33 120M	900	1,600	1,150	–50
Clone Notebook 286, 40M	350	750	525	–25
Clone Notebook 386SX, 40M	500	950	750	+75
Clone 386/25 80M, VGA	450	950	575	–50
Clone 386/33 80M, VGA	550	1,050	700	–25
Clone 486/25 120M, VGA	800	1,450	950	—
Compaq SLT/286 20M	250	500	350	—
Compaq LTE 286 40M	400	775	525	—
Compaq Deskpro 386/20e, 100M	500	700	650	+50
Compaq Contura 320, 60M	400	1,000	875	–100
Macintosh Classic, 40M	350	650	425	—
Macintosh SE/30, 40M	375	800	525	+25
Macintosh II, 40M	400	750	600	+50
Macintosh IIcx, 80M	500	900	525	–75
Macintosh IIci, 80M	700	1,100	925	—
Macintosh IIfx, 80M	800	1,800	1,400	–100
PowerBook 100, 20M	525	900	650	+50
PowerBook 140, 40M	900	1,400	1,000	—
PowerBook 170, 40M	1,200	1,900	1,450	–50
PowerBook 180, 80M	1,600	2,300	2,100	+100
LaserWriter IINT	700	1,000	750	–50
Toshiba 1200XE	300	650	375	+25
Toshiba T-1900, 120M	1,000	1,700	1,350	–125
Toshiba T-3200SX, 100M	400	800	550	–100
Toshiba 5200, 100M	850	1,250	1,000	—
HP LaserJet II	400	850	600	—
HP LaserJet IIIP	375	950	575	+100
HP LaserJet III	750	1,100	925	+50
HP LaserJet IV	1,000	1,300	1,250	–50

come to expect new generations of computers to be 200% to 500% faster. Recent benchmarks of the 60-MHz Pentium chips show them to be only 30% to 50% faster than top-level 486 chips running at 66 MHz. The Pentium should get a significant speed boost next year. Unlike most speed enhancements, this one won't be due to an increase in clock speed, but to an improvement in its caching system. Intel is working hard to catch up with the speed of the Motorola PowerPC 601 CPU chip, said to run up to 50% faster than the current Pentium. Meanwhile, Motorola plans to ship the next generation of the PowerPC chip before the end of this year. The PowerPC 620 will be a 64-bit chip capable of running five times faster than the present PowerPC 601.

During 1991, the Big Three computer makers—IBM, Apple and Compaq—began cutting prices to compete with low-cost clones. At that time, many people predicted the demise of most of the clone makers. While it's true that Tandy, Everex and a few others have exited the business, several others have remained far longer than many people predicted. Why would anyone purchase a clone when he could buy a name-brand computer at a comparable price? The survivors exist primarily because the Big Three can't manufacture enough computers to meet the demand. Some experts believe this backlog of orders will disappear early next year, due to increased production facilities. Ample supplies of name-brand computers could be the death knell for the remaining clone makers. The resulting oligopoly will surely result in higher prices and better profit margins for the victors of the shake-out.

Apple Computer is expected to completely revamp its line of computers during this year. None of the new computers are expected to use the Motorola 68030 CPU chip. Some of the new models will use the more powerful 68040 CPU, while others will run the faster PowerPC CPU chip. A new PowerBook is expected with a low-power version of the 68040. Called the 68RC040, the new chip should run at 25/50 MHz.

Recent increases in prices of memory chips have been due to a shortage of epoxy resins. While this shortage has been eliminated, many people expect memory prices to continue to increase. Some say prices could be 30% greater in the next six months. These increases are due to exploding demand. Because memory costs can be 15% or more of the cost of a new computer, new systems prices should rise accordingly. Some memory-intensive applications and operating systems are experiencing poor sales due to expensive upgrade requirements. Some computer retailers have stopped stocking Microsoft's *Windows NT* due to poor sales. Microsoft may be forced to market a smaller, more-limited version of the operating system that would require less than 20M of RAM memory.

Many computer users feel that they have no need for some new technologies like voice synthesis and voice recognition. New applications of these technologies may change their opinions. For example, QVoice Inc. in Newton, NJ, has developed an inexpensive voice security system. Based on voice recognition, it identifies the voice of the appropriate user and only then permits access to the system. This eliminates the need for password protection.

IBM is expected to soon announce its new Personal Dictation System. Composed of both hardware and software, the system could be one of the best speech-recognition systems to enter the marketplace. It seems to have the ability to determine the appropriate spelling of most homonyms, based on grammatical usage. The first

version of the system will work on desktop computers that use IBM's OS/2 operating system. Another version of the system may appear in summer in the form of a PCMCIA card. These small cards can fit many notebook computers. It would most likely be offered as an option for the IBM ThinkPad notebook computers. IBM is expected to announce a smaller pen-based computer next year. The ValuePen will rely primarily on handwriting recognition for input. However, if the new speech-recognition package is included, it could be the first to recognize both handwriting and speech.

More News

In the computer industry, 1994 may become known as the year of the light, powerful and, possibly, inexpensive notebook computer. Compaq is expected to announce a new Contura notebook soon. The new computer weighs less than 4 pounds and uses a 25-MHz 486SL CPU chip. The surprising news is the price. With 4M of user RAM and a 120M hard drive, it's expected to sell for less than $1,500. Other surprises may be in store from Compaq as the Number 3 computer maker vows to become Number 1.

Apple is expected to completely revamp its line of PowerBook notebook computers in 1994. Its lowest-priced model will sell for $1,200 and sport power and capacity comparable to the Compaq Contura. Its more-powerful models will utilize 68040 CPU chips, instead of the slower 68030 CPUs. The new notebooks are expected to have two available bays to permit use of two batteries or one battery and a variety of expansion options. During the fall, some of the 68040 notebooks may be upgraded to the new PowerPC CPU chip. These could easily be the most-powerful notebook computers on the market. If the PowerPC chip lives up to expectations of running both *Windows* and Macintosh software, Apple may have another runaway best seller on its hands.

The giants of the computer industry, Microsoft and Intel, have both experienced lackluster sales with their latest products. Microsoft's *Windows NT* operating system and Intel's Pentium CPU chips may become more popular when applications begin to utilize their advanced functionality. In the meantime, each company is promoting some older technology. Microsoft fears an increasing popularity in IBM's *OS/2 for Windows*. This inexpensive operating system provides many of the 32-bit functions of *Windows NT* but without the greater hardware requirements of *NT*. Consequently, Microsoft is making a major push for *Windows for Workgroups*. It has convinced several vendors to preinstall this version of *Windows* on new machines, Vendors include Dell, CompuAdd, Gateway, Digital Equipment and Toshiba. Some people fear that Microsoft is promoting this version to stem OS/2 sales due to incompatibilities between the two products.

Meanwhile, Intel is expected to introduce several new versions of the 486 CPU chip. These faster versions may run as fast as 100 MHz. At this speed, the chips may approach the performance of low-end Pentium processors. This may stimulate sales until cheaper, faster Pentiums are available.

Apple recently celebrated the tenth anniversary of the Macintosh with the comforting fact that it's shipping more computers than any other manufacturer. Currently, its shipments are 24% greater than IBM's and 62% greater than Compaq's.

Microsoft and Apple will soon be entering a new market of on-line computer services. Competing with the existing services offered by Prodigy, CompuServe and America Online, Microsoft's new service is expected to be called MicroServe. Apple's service has been announced as eWorld. Each company realizes the enormous profit potential of these services. This potential may explode in a few years, with access through interactive television. In addition, each company is hoping to position its graphical interface as the standard in interactive TV. If a true standard should emerge through TV, it would most likely be adopted in future versions of home appliances and office equipment.

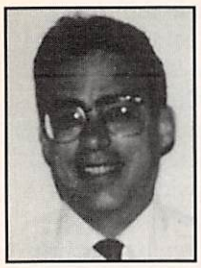
Computers communicate with video monitors, printers, modems and the outside world in general through cards plugged into slots on the computer's motherboard. Most computers have ISA slots, which were developed for the first 286 computers and, thus, are the cause of a bottleneck for data in most of today's high-performance Intel-based personal computers. IBM attempted to alleviate this bottleneck with its proprietary Micro Channel slots. Most other manufacturers didn't choose to license this technology from IBM. While providing higher performance levels than ISA, even Apple's NuBus slots on the Macintosh will limit throughput on the new, faster family of PowerPC computers due to hit the market this year. It appears that most manufacturers will adopt a new standard within the next year. The PCI slot developed by Intel should eliminate bottlenecks in most computers. In addition, cards may finally be interchangeable between Macintoshes, PS/2s and clones.

Apple and Texas Instruments have announced a new standard for high-speed serial ports that could work in conjunction with the new PCI slots. Using thin, inexpensive cables, the new ports would support connection of external hard drives, scanners, printers, VCRs, camcorders, stereos and networks.

For 10 years, Apple has had a less-than-strict rule against its authorized resellers marketing the Macintosh through mail-order channels. This ban is expected to be lifted by the time you read this. Open use of mail-order may result in lower prices on many new Macintosh computers.

Laser-printer resolution is measured in dots per inch, or dpi. More dots means better resolution. Several years ago, most desktop laser printers produced 300-dpi resolution. Today, most printers in the desktop laser category produce 600 dpi of resolution. Hewlett Packard was recently awarded a patent for a technique that allows 600-dpi printers to produce up to 1,200 dpi of resolution for very little additional cost. It may slow the printing speeds at higher resolution, but the higher resolution can also be toggled off and on as needed. Printers with the new feature may be on the market in less than a year.

PASport is a new software package from Shrinkwrap Software Ltd. that gives *Windows* users the ability to employ a fax machine as a printer or scanner. Notebook-computer users may find it handy when they're away from home.



By Joe Desposito

Computing On the Go

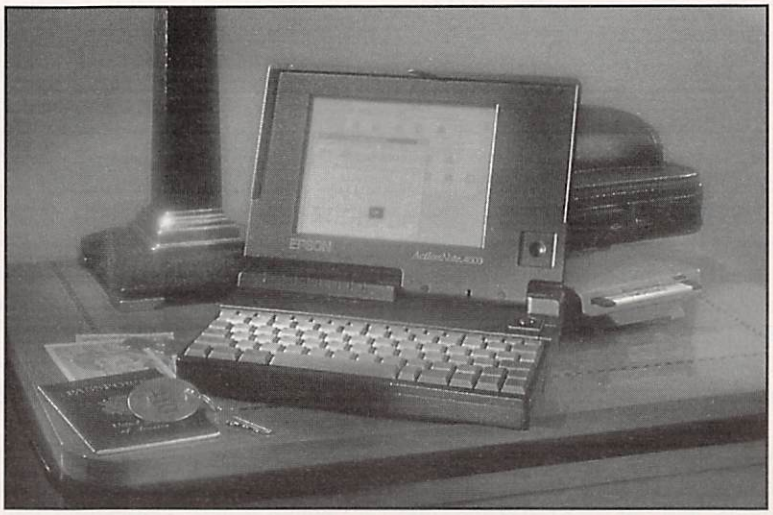
Beating the Weatherman at His Own Game

Although this column appears in this May/June issue of *MicroComputer Journal*, it was written on a snowy February day in New York City. On this day, most people either stayed home from work or had lots of difficulty making it into their offices. With schools closed, kids were home. Naturally, I had no problem getting my work done. Although I do most of my work out of an office, on treacherous days like this, I simply work at home.

Working at home and on the road has become even more convenient than ever for me since I latched onto a couple of subnotebook computers to review for this column. No matter what the forecast, and it has been the coldest and snowiest winter in memory here in the Northeast, the forecast for work was bright lights and warm room temperature. My productivity has soared, thanks to these wonders of miniaturization.

You might be thinking, "What's the big deal? You can work at home with any size computer." This may be true, but I find the subnotebook computer an especially convenient device for moving from room to room to avoid distractions, for taking to another location altogether and for working in the car on long trips, the last with someone else driving, of course. A subnotebook computer isn't essential to do these things, and a notebook or laptop will work as well. However, being that the subnotebook is a much smaller package, you're more likely to take it along with you, I believe.

I wrote this column on a Hewlett-Packard OmniBook 300. The particular configuration I have is likely to become the standard for computing in the future, though I had lots of trouble with it until I worked out the bugs. The other subnotebook I worked with was the Epson ActionNote 4000, which I'll have more to say about later. I'll tell you right up front, though, that I've been using the Epson for the bulk of my work for the past three months.



Hewlett Packard OmniBook 300 subnotebook PC.

Epson OmniBook 300

Epson's OmniBook comes in several configurations. The one I have makes the most sense, for the future, that is. The system contains 10M of ROM that's programmed with: DOS 5.0; DoubleSpace; Microsoft *Windows* 3.1, *Word* 2.0 and *Excel* 4.0; and HP Phone Book, Appointment Book and Financial Calculator. This ROM resides on a PCMCIA card that fits into one of the OmniBook's four PCMCIA slots. (Three Type II and one Type III PCMCIA slots are provided.) HP also includes a 10M Flash memory PCMCIA card in another slot.

DoubleSpace, as its name implies, is used to double the available storage space. All of the storage space in this configuration of OmniBook is silicon (no electromechanical drives). When you turn on the computer and check the drive icons in *Windows*, you see a C: drive with about 20M, a D: drive with about 10M and an E: drive with about 10M. In future, these numbers are likely to be 10 times greater.

Other features of the 2.9-lb. OmniBook 300 include a 20-MHz 386SXLV CPU, 9" enhanced reflective LCD (no back light), 2M of RAM that's expandable to 8M, nickel-metal-hydride battery that can be fully charged in about 2 hours and an ac adapter/battery charger. This configuration runs for about 9 hours on the included rechargeable battery. You also can use standard AA alkaline cells or the ac adapter to power the computer. OmniBook 300 has a street price of about $1,800.

Why is this configuration wrong for today? Simply because the it has no floppy drive (though you can obtain one from a third party vendor if you feel you need it). Hewlett-Packard has done its best, though, to find a workable solution to data transfer. It's that old reliable software package, *LapLink*.

Several years ago, I was using *LapLink* all the time. In recent years, I was glad to be rid of it. OmniBook comes with *LapLink Remote* in ROM and a cable to make serial connection to a desktop computer. Actually, the concept is ingenious. You connect together the OmniBook and desktop computers with the cable, start *LapLink Remote*, respond to a few prompts and another *LapLink* program is automatically installed on the desktop system. When *Windows* is

running on both computers and the two are interconnected through *LapLink*, you have access to all drives on both systems and can easily transfer files between them with the *Windows* Program Manager.

Unfortunately, arriving at this point took me so long that I was ready to send OmniBook back for a replacement. After all, if I can't get programs and files into and out of the darn thing, what good is it? My first attempt at using *LapLink Remote* resulted in an error message that informed me the desktop system wasn't responding. After a few tries with no luck, I called HP for some technical assistance. The support person narrowed the problem to the 9-to-25-pin adapter I used to get the HP cable to connect to my ALR Power desktop (the HP cable has nine-pin female connectors on both ends). Though the adapter worked fine with my mouse, the support person told me that it might not have the wires connected properly on all nine pins. I didn't really believe this, figuring that the cable or OmniBook's serial port had to be at fault. In any case, I told the tech person that I'd try to dig up one of my old *LapLink* cables that had nine- and 25-pin connectors on both ends.

With all the work I had to do, I just put OmniBook aside, disappointed that it couldn't be of more use to me at the time. Meanwhile, I was using the Epson ActionNote for just about everything. With the pressure of the deadline for this column nearing, I knew I had to play around with OmniBook until I got it to work. After locating my old *LapLink* cable, it suddenly dawned on me that I could connect the Epson's nine-pin serial port to OmniBook just to see if the adapter was truly the cause of the problem. Sure enough, once I connected together the two subnotebook computers, everything worked fine. Score one for HP tech support!

Once you get it going, *LapLink Remote* works wonderfully well. There isn't even the small learning curve that was associated with the older DOS version of *LapLink*, since you work exactly the same way you do with the *Windows* Program Manager. No matter how well it works, though, I just don't like connecting a cable every time I want to transfer a file and then having to disconnect it when I'm done. So I decided to try the alternate approach, as long as I had the two sub-notebooks on the same desk—PCMCIA transfer.

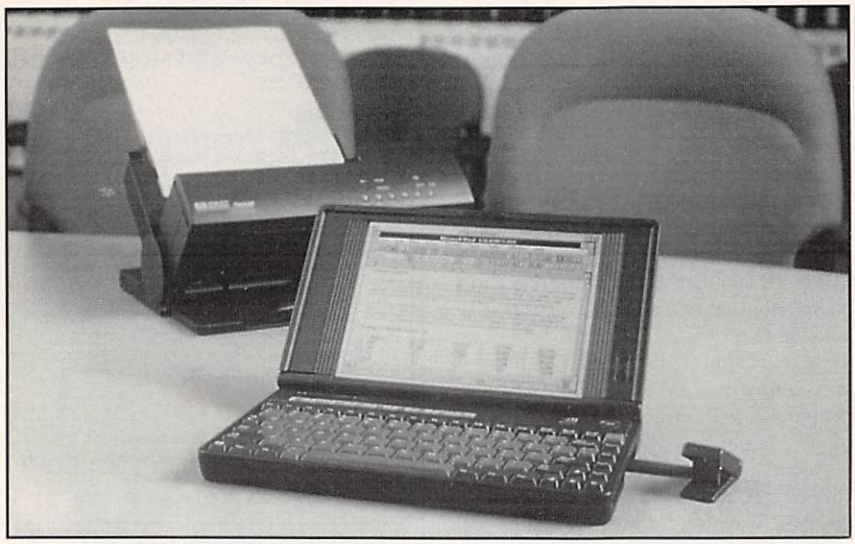
A little aside is in order here. OmniBook arrived without its usual documentation. Undaunted, I fiddled around with it anyway. I even loaned it to a student friend of mine to type a short paper. She saved the file, which I promised to print out as soon as I got the opportunity to do so. In the meantime, I popped out the two PCMCIA cards that come with the unit and looked them over. When I put them back in, OmniBook was dead. I thought it was the battery. Without the charger at hand, I attempted to install AA cells, which OmniBook can use. When this didn't work, I was really puzzled as to what had happened. I think my reputation fell a few notches when I couldn't print out the paper. Later, I found out from HP tech support that the two PCMCIA cards that come standard with OmniBook can't be inserted and removed as you normally are able to do with these cards. Whenever these two cards are removed, you must press a tiny reset switch nestled between the parallel and infrared ports at the rear of the computer.

Normally, PCMCIA cards can be slipped into and out of their slots in much the same way as a floppy disk can be slipped into and out of its drive, whether the computer is on or off. Both the Epson and HP subnotebook PCs have PCMCIA slots, and I had a SunDisk 1.8M FlashDisk that Tandy had loaned me for use in the Zoomer. Transferring files using the SunDisk card worked great.

I copied some files from the Epson ActionNote to the SunDisk card, removed the card and placed it in the HP OmniBook PC. Then I called up the files right from the SunDisk. Being that this is a flash disk, files don't have to be transferred to a faster medium as you would normally do with a floppy/hard disk arrangement. On OmniBook, if you have the *Windows* Program Manager on the screen, you'll see a small PCMCIA disk-drive icon. When the PCMCIA card is plugged into the slot, the icon immediately changes to one that has a card in it.

OmniBook has a few notable features worth mentioning before I move on. Instant-on brings you immediately to the screen on which you last worked when you press the On/Off key. This is a real time saver. Another excellent feature is the keyboard. It has a great feel and layout. I had no problems with it whatsoever. A row of icons lies on the keyboard, just above function keys F1 through F9. Pressing a special Fn key plus the appropriate function key lets you easily switch between applications. The ac adapter/charger is notable for its lack of indicators. Instead, a battery icon pops up on the screen to display the status of the charge and whether or not the adapter is connected.

Finally, OmniBook's mouse is different from any I've ever experienced. It looks like a miniature mouse, but it's attached to OmniBook by a piece of black plastic that looks like a small ruler. The mouse acts as a handle for this piece of plastic. The mouse has no ball on the bottom, but it has a top that pops up if you want a better grip. I found it to be a better solution than



Epson ActionNote 4000 subnotebook computer.

a miniature trackball, but not nearly as good as a conventional mouse. If you don't like the built-in mouse, a conventional one can be connected to the serial port. OmniBook automatically senses the external mouse and disables the built-in one. HP includes a program for changing the size of the mouse cursor, which is a help on the monochrome LCD screen.

Hewlett-Packard has already upgraded OmniBook. The newest model is the 425, which has most of the features contained in the 300, but it includes a 25-MHz TI-486SLC/e CPU. I think if I had a PCMCIA drive in my desktop PC, I'd have used OmniBook much more than I did. But this is something to consider for the future.

ActionNote 4000

The other subnotebook PC I had an opportunity to play with was Epson's ActionNote 4000. I used this PC much more than I did OmniBook for a simple reason. It comes with an external 3½" floppy-disk drive. With this, I was able to install two programs on ActionNote's 120M internal hard-disk drive, *PageMaker* 4.0 and *OrCAD*. Like many other subnotebook PCs, ActionNote 4000 has a built-in miniature trackball that substitutes for a mouse. It was easy enough to become accustomed to this device, but I found it terrible to work with, especially in the programs I was using, which are extremely mouse-dependent. Not until I discovered that I could disable the trackball and attach a standard mouse was I able to get some real work done.

When I first began using ActionNote, I found its speed to be real drawback. I hadn't expected speed problems from this 33-MHz 486-powered machine. It turns out that the problem was caused by ActionNote's power-management features, which were powering down the hard disk after one minute. Fortunately, this is adjustable, as is almost every other facet of the machine. To get around the problem, I plugged in the ac adapter, turned off the power-management feature and raised the hard disk's timeout to 10 minutes. This is all done through the setup program, to which you gain entrance by pressing the Delete key at startup.

I very much liked ActionNote's flexibility. Besides the mouse, you can substitute an external keyboard and VGA video monitor. I did most of my work with just the external mouse added. I was able to work to about 95% of normal in *PageMaker* and *OrCAD*. The back-lit LCD screen, although measuring only a 7.4" diagonally, was sufficient for my needs and should be so for the great majority of other people's needs. The only drawback is that you can lose sight of the cursor every so often.

I disliked the Epson keyboard. When you don't have to enter much text, as in the two programs I was using, this isn't a significant problem. However, I wouldn't write this column or any long piece of text on ActionNote. One of the main difficulties concerns the position of the right-hand shift key. It's at the farthest-right point of the keyboard, and it's not much bigger than any other key.

Between the slash (/) and Shift keys is the up-arrow key. Frequently, when I tried to shift the keyboard, it was easier to hit the up-arrow key, moving the cursor up a line. Consequently, I often found myself typing text in the wrong place. To correct my natural tendencies, I picked off a tiny piece of a glue stick and attached it to the Shift key to give my pinky something feel when reaching for the Shift key. All in all, this worked pretty well.

Another problem with the keyboard is the resistance of its keys. To me, they were difficult to press down. Of course, keyboard "feel" is generally a personal-preference situation and, thus, other people who use Action Note's keyboard may not feel as I do about it.

You can solve keyboard problems by substituting a different keyboard. However, there's a minor drawback associated with doing this. The connector on ActionNote for an external keyboard is a miniature socket. Since the keyboard on my office PC (and I'd hazard the great majority of every other desktop PC) uses the standard plug, an adapter is required to effect the connection. My home machine is an upgraded IBM PC, which means that the keyboard isn't even compatible with ActionNote. One of my friends owns a Gateway 2000 486SX-33, which is one of the few PCs that have a keyboard that's equipped with a miniature plug. So I was able to use it with ActionNote. The substitute keyboard worked fine.

When I plugged in the external video monitor, it didn't work, as well. I found the VGA display to be somewhat blurry and wavering on the Gateway SVGA monitor. So I decided to try the 4000 with the NEC Multisync at my office. This external monitor worked perfectly. Most SVGA monitors have only two syncing frequencies, one each for VGA and SVGA. The Multisync, on the other hand, can scan a range of frequencies, which is probably the reason for the better performance I got from it. If you wish, you can have the display show up on both the built-in and external displays, which is convenient for presentations.

I don't want to give the impression here that ActionNote 4000 can't be used without an external mouse, keyboard and video monitor. This is certainly not the case. In fact, under deadline pressure, I used the 4000 in the back seat of a car to edit an article in *PageMaker*. This isn't the best way to do things, but it can be done in a pinch. When the circumstances aren't so dire—for instance, a deadline that isn't so close and working on a kitchen table—I found it preferable to substitute the external mouse.

As mentioned earlier, the Epson ActionNote was the computer I used to derive some utility from the HP OmniBook. I moved files from the desktop PC to ActionNote through its external drive and from ActionNote to OmniBook via the PCMCIA SunDisk Flash card. This latter transfer worked flawlessly. Flash cards sure look like they have a bright future.

I tried one other PCMCIA card in ActionNote, the Epson 2400/9600 Fax/Mo-

dem Card. All you need to do to get this one up and running is slide the card into the slot, and you're ready to communicate. Epson supplies the cable that connects the PCMCIA card to the telephone line. The cable is a bit short. For a long run, you need a dual-female RJ-11 connector to add a longer telephone wire to the one supplied.

Included with the Fax/Modem Card is a communications program called *COMit* and the *WinFax Lite* and *DOSFax Lite* programs. If you haven't heard of *WinFax Lite* or its more-powerful sibling, *WinFax Pro*, this software can send a fax directly from any *Windows* application. The program accomplishes this by providing its own printer driver. Unfortunately, this driver outputs a slightly different page format than other printer drivers as, for example, the Apple Laser Writer IINTX. This flaw probably won't be a problem in many cases, when you're simply trying to deliver a message with a fax. But for desktop-publishing applications in which position, as well as content, is of utmost importance, *WinFax* is useless. I was hoping this program could solve a major problem of mine. The office fax machine can transmit a maximum of six pages at a time. With *WinFax*, you can send as many pages as you want. But the pages composed by *PageMaker* for *WinFax* were different from those composed for the IINTX. So I had to return to the fax machine and keep looking for a solution. By the way, this limitation occurs only when *sending* a document through *WinFax*. If you receive a document sent from a standard fax machine, you'll obtain the actual image.

Some of the standard features of the 3.8-lb. Epson ActionNote 4000 are: 33-MHz 486SLC processor; 4M of RAM that's expandable to 8M; 120M removable hard-disk drive; one PCMCIA Type II slot; back-lit VGA 7.4" LCD monochrome display screen; built-in two-button trackball; Ni-Cd battery; and ac adapter/charger. The system comes pre-loaded with *Windows* 3.1 and MS-DOS 6.0. System street price is around $1,500.

PCMCIA SCSI Card

If you're trying to figure out how to connect external SCSI devices, such as a CD-ROM drive, to a notebook computer, Future Domain has the answer with its 16-bit SCSI2GO PCMCIA Type II SCSI controller. SCSI2GO is capable of FAST SCSI-2 transfer rates up to 10 M/s. The device features Future Domain's 18C30 single-chip SCSI-2 controller with 2K internal FIFO buffer. The interface cable is an SCSI one with locking PCMCIA card connector on one end and 50-pin SCSI-2 connector on the other end.

Products Mentioned

OmniBook 300
Hewlett Packard Co. Inquiries
1000 N.E. Circle Blvd.
Corvallis, OR 97330
Tel.: 800-443-1254
CIRCLE NO. 126 ON FREE INFORMATION CARD

ActionNote 4000
Epson America, Inc.
20770 Madrona Ave.
Torrance, CA 90509
Tel.: 800-289-3776
CIRCLE NO. 127 ON FREE INFORMATION CARD

SCSI2GO
Future Domain 2801
McGaw Ave.
Irvine, CA 92714
Tel.: 714-253-0400; fax: 714-253-0913
CIRCLE NO. 128 ON FREE INFORMATION CARD

Cover-LOC Card Kit
R&D MICRO, Inc.
23392-A Madero Rd.
Mission Viejo, CA 92691
Tel.: 714-830-1387; fax: 714-951-5422
CIRCLE NO. 129 ON FREE INFORMATION CARD

SCSI2GO has a powered-down sleep mode. While operating, it has a power requirement of only 210 mW. As with all Future Domain SCSI controllers, SCSI-2GO is fully supported by PowerSCSI!, the universal application interface under DOS, *NetWare* and *Windows*. Embedded support is provided in *Windows NT* and OS/2. SCSI2GO will be included in the SCSI Valuepak and CorelSCSI Kit. Suggested retail pricing of the kits are $329 and $389, respectively.

PCMCIA Card Kit

Anyone who wishes to try his hand at developing a PCMCIA device can do so with R&D MICRO's PCMCIA Type II Cover-LOC Card Kit. This kit can be utilized in conjunction with your own PCMCIA design concepts. The assembly has a 15-position I/O port and mating cable assembly.

The kit includes a frame assembly with ESD clips, cable assembly and covers. The frame assembly can accommodate the following 68-pin connectors: Duont, JAE, JST and Methode. Additionally, the circuit board can be configured for offset or centerline position.

Cover-LOC snap-fits to the frame assembly, eliminating heat activation, heat staking or pressure-sensitive lamination of circuit substrate to the frame assembly. Suggested kit retail price is $27. Maybe we'll see a PCMCIA project in *Micro-Computer Journal* in the not-to-distant future? ■

Microcomputer Q&A

By TJ Byers

In this column, I answer your questions about all aspects of computer disciplines, both hardware and software, plus related electronic queries. Since I draw from a large source of knowledgeable contributors, feel free to ask whatever questions you may have regarding computing on the PC platform. If you have a problem you'd like to have solved or a question you want answered, you can send it to me at *MicroComputer Journal*, 76 N. Broadway, Hicksville, NY 11801.

No Color on Power-Up

Q: *I'm having problems with my VGA color display. When I turn on my system, the screen comes up in monochrome instead of color. If I press the RESET button, color is restored. Do I have a bad video card or a bum monitor?*
A: Neither. It's the way you sequence initial start-up. VGA color monitors have a special signal that identifies them as being color. Monochrome VGA monitors don't have this signal. Most video cards look for the monochrome/color signal when you power up or reboot your system. If the color signal is missing, the card defaults to monochrome. To solve the problem, all you have to do is turn on your video monitor *before* you turn on your PC.

Which SmartDrive Do I Use?

Q: After updating to DOS 6.2, I noticed that I now have a SmartDrv.COM and a SmartDrv.EXE in my DOS directory and a SmartDrv.EXE in my *Windows* directory. They all have different dates. Which one do I use and how?
A: Use the most current one. From the DOS prompt, type:

```
DIR C:\DOS\SMARTDRV.*
DIR C:\WINDOWS\SMARTDRV.*
```

and compare the dates and time. *Windows* 3.1 is newer than DOS 5.0, but DOS 6.0 is newer than *Windows* 3.1. DOS 6.2 is the newest and is equivalent to SmartDrive in *Windows for Workgroups 3.11*. The least-painful way to make the upgrade is to place a copy of the newest version in both your \DOS and \WINDOWS directories. This way, you shouldn't have to edit your CONFIG.SYS or AUTOEXEC.BAT files.

SmartMon Fine Tunes SmartDrive

SmartMon is a *Windows* companion application to the SmartDrive disk-cache utility. It provides visual indication of cache activities and allows you to alter the properties of the cache for best *Windows* performance. Using SmartMon, you can manipulate the run-time parameters of SmartDrive on the fly and monitor the effect on cache efficiency. SmartMon can also save the changes in the batch file that contains the SmartDrive command.

SmartMon's functionality is organized visually into four main groups—Cache Memory Controls, Drive Caching Controls, Cache Hit Rate Display and Options and Cache Activity Logging—as detailed in Fig. 1. The Help screen describes their use. To install SmartMon, all you have to do is open up the File Manager from the Main menu and locate SMARTMON.EXE in the *Windows* directory. Now drag and drop the SmartMon icon into a Program Group, such as Accessories.

WordPerfect for Windows 6.0 Bug

Q: *I'm having a lot of trouble getting* WordPerfect for Windows *6.0 to run. Until two weeks ago, it ran without a problem. Now, when I launch it from the icon in Program Manager, I get the error message: "WPWIN60.EXE has caused a General Protection Fault in module SHWINC20.DLL at 0001:14F3." I called WordPerfect's BBS and found that many others have the same problem. I tried the upgrade posted on the BBS, but the problem persists. Does anyone have an answer? It sounds like a* huge *bug, since others report the exact error message.*
A: It sounds like your problem is a corrupt .BIF file. This is a recognized bug in the program, which should be fixed in the interim release, due out "any day now." Be sure to call WordPerfect customer support on this problem and insist that an official Problem Report be filed in your name. If you do this, the company will send you the updated version at no charge.

Meanwhile, you can probably get *WordPerfect for Windows* 6.0 back on its feet if you rename the .BIF file, which should be stored in your \WINDOWS directory, with a different name and then restart *WordPerfect for Windows* 6.0. This should fix the problem, but you'll lose all the customizing you've done to your interface—along with most of your other custom settings. *WordPerfect* will revert to its default settings.

Certified Computer Technician

Q: *I'm the owner of a small computer sales/service center. I'd like to know if there are any professional testing/certification organizations for computers. Certification lends an air of professionalism to any occupation, and I'd like to pursue this avenue.*
A: Unfortunately, I can't find one. There are several software companies that do testing and certification, including Novell and Microsoft Consulting. But no organization is specifically targeted for the computer technician. Of course, a CET (Certified Electronic Technician) certificate is nothing to scoff at, but it requires a good knowledge of radio and TV theory.

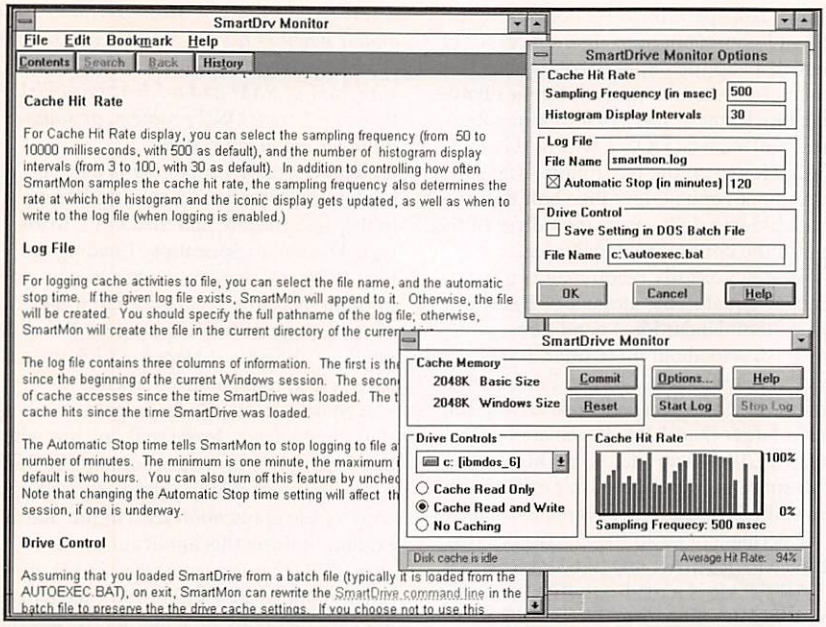


Fig. 1. SmartMon's functionality is organized visually into four main groups — Cache Memory Controls, Drive Caching Controls, Cache Hit Rate Display and Options and Cache Activity Logging.

An alternative would be to earn an Associate diploma from a community college or recognized correspondence school, such as Cleveland Institute of Technology, that you can hang on your wall with pride.

Redirect Printer Output To A File

Q: *I'd like to know how to configure my printer ports to send print output to a file, rather than to LPT1. I use* Windows.
A: This is easily done via the *Windows* Control Panel. First click on the Main icon and open the Control Panel option. From here, bring up the Printers menu and select Connect (Fig. 2). You can now redirect your printer output to any port or file you wish. Since the File option is farther down the list, you'll need to use the scroll bar to find it.

CD-ROM Sound

Q: *I'm confused about the audio facilities on a CD-ROM. What are the phono jacks in the back used for? I tried to plug them into my home stereo, but only some CDs work—most don't. A friend says I need a sound card, like the Sound Blaster. But I already have a CD-ROM card that came with the drive plugged into a slot. What's wrong with my setup?*
A: Sound recorded on a CD-ROM is divided into two broad types: music files and DOS files. As the name implies, music files are encoded analog sounds in the format used by the music industry. These CDs will output to the phono jacks and play through your stereo without requiring a sound card.

Nearly all CDs that carry computer programs use digital audio stored in the form of .WAV or some other DOS file format. Playing these files requires a sound card that contains the necessary digital-to-analog (D/A) converter circuitry. A dead giveaway is the MPC logo on the software, which demands the presence of a sound card, and you'll get no audio without one. Once the files are converted from their DOS format, the sound exits via the sound card's audio output ports, which will now play through your external speakers or stereo system. The sound card also includes a mixer that lets you combine CD audio (from the drive) with digitized audio and synthesized music from the sound card's microphone or other sound source.

The card that came with your CD-ROM drive is the drive's controller, not a sound card. However, almost all MPC-compliant sound cards have CD-ROM controllers built in (though some are proprietary and work with only certain drives). So depending on your drive, you could replace your existing controller with a sound card that has a compatible controller, thus saving an expansion slot. But there's no law against having a sound card *and* a controller card coexisting in your PC. Prices for decent sound cards start at around $100.

All About *Windows* Permanent Swap File

Q: *I recently upgraded my system to DOS 6.0 and DoubleSpace. Now things are falling apart. First, icons started disappearing. Then the message "Corrupt Swap File Warning. You need to create a new swap file. Choose the 386 enhanced icon in windows. Do you wish to delete the corrupt swap file? Y or N?" popped up on the screen. So, I went back into the Control Panel and tried to create a new swap file. I changed all the options to my preference and chose "OK." It restarted* Windows, *and the same error message*

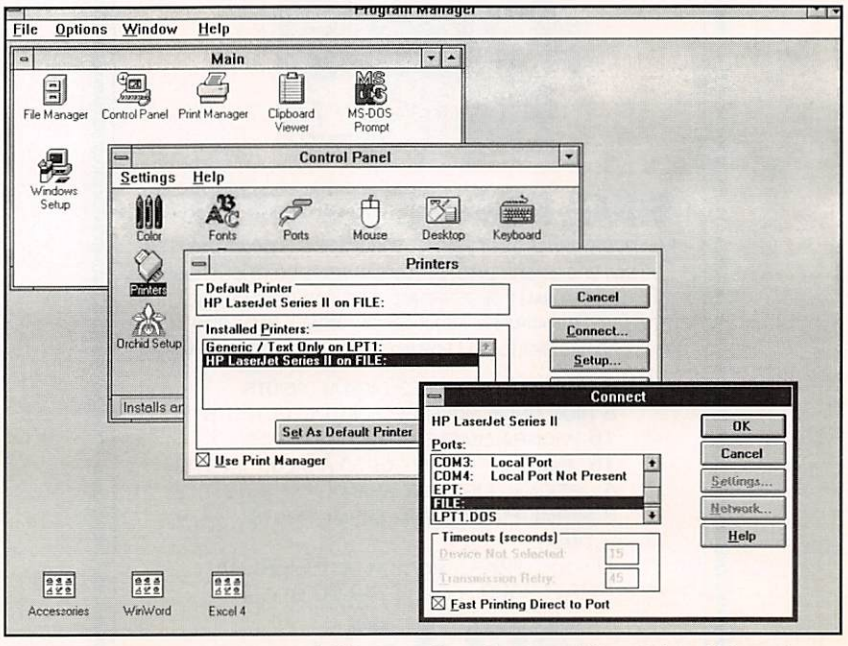


Fig. 2. To redirect printer output in Windows, from the Control Panel, first click on the Main icon and open the Control Panel option, bring up the Printers menu and select Connect.

came up again. I tried this several times, each time with the same result. I even tried deleting the swap file. The only way I could get rid of the message was to set my swap file type to none. Finally, the Control Panel and Setup icons were gone, forcing me to reload Windows. *But the same thing started all over again.* Help!

A: Using a permanent swap file, one that uses your hard disk to emulate system RAM, improves the speed of *Windows* because it lets you run large applications that take more memory than system RAM can provide. But, as you and many others have discovered, it has its problems.

Swap file works only with disk drives that use 512-byte sectors partitioned with the DOS FDISK utility. If you use a partitioning utility that's installed as a driver in CONFIG.SYS, such as DoubleSpace, you're asking for trouble. If you receive a message that the swap file is corrupt, make sure that you're using the FDISK partitioning scheme—not one that compresses the disk. If you're using a compressed drive, use the Control Panel to delete the swap file and recreate it on an uncompressed drive.

Swap file displays two values concerning the hard-disk driver: the largest possible swap file size and the total amount of free disk space. The largest possible swapfile size is the largest available block of free contiguous sectors. The total amount of free disk space includes both contiguous and non-contiguous disk space. A permanent swap file requires contiguous disk space. To create a larger contiguous hard-disk block space, run a disk-optimization program, such as DOS's DEFRAG or *PC-Kwik*. However, the maximum swap file size can never be larger than half the available free disk space, regardless of the size of the contiguous block area.

Windows usually recommends a swap file size equal to the amount of RAM in the system. Under ideal conditions, you can push it to about three times larger than system RAM, but not larger. For example, on a 4M system you can't use a swap file that's larger than 12M. If you choose to create a 20M swap file, you'll be wasting disk space because there isn't enough linear address space to access the extra 8M.

A permanent swap file consists of two parts: SPART.PAR and 386SPART.PAR. SPART.PAR is a read-only file located in the *Windows* directory. 386SPART.PAR is a hidden file located in the root directory of the drive. If all else fails, delete the *Windows* directory using DELTREE and delete the hidden file using a combination of the ATTRIB -h 386SPART.PAR and DEL 386SPART.PAR commands. Then reinstall *Windows* from scratch.

Slow OS/2 *Windows*

Q: *When loading* Windows *applications, it seems to take forever. Moreover, it doesn't matter whether it's the first, second or last application loaded. I have a 486DX-66 PC with 16M of RAM and a 530M hard disk. Is this an inherent OS/2 problem, or something wrong in my system?*

A: What's really happening is that you're loading a DOS session, starting *Windows* in the background, and then OS/2 loads your *Windows* application. Loading the next *Windows* application has to go through the same procedure. So it takes about as long as booting up your PC with DOS and *Windows*. Here's a trick the experts use to reduce the overhead.

Run a small *Windows* program, such as Berkeley's *After Dark for Windows*, when you first power up your computer in OS/2. You can automate the process by adding a copy of the application icon to the Startup Folder. Starting this application will be slow. But when you start the next *Windows* application, OS/2 doesn't have to load another copy of *Windows*. It runs the new application in the same *Windows* session, which speeds up things considerably.

Recycling Lost Clusters

Q: *When I run CHKDSK, I get the following message:*

```
Errors found, F parameter not specified
Corrections will not be written to disk

3075 lost allocation units found in 25
chains.
6297600 bytes disk space would be freed
```

I really need that 6M of disk space back. What's wrong and how can I fix this?

A: CHKDSK isn't one of the best disk doctors around, but it comes free with DOS. It's primary function is to check for lost clusters (allocation units) that have been marked as unusable by DOS's File Allocation Table (FAT). Lost clusters most commonly occur when a program crashes. If the lost clusters are a result of a recent program crash or operator error, and you want to recover the files, don't run CHKDSK. Instead, use a disk-recovery utility, such as *Norton Utilities* or *PC Tools*, from a floppy disk.

CHKDSK won't recover the damaged file. It simply puts the lost clusters back into circulation for use again. To recycle the lost clusters, specify the /F switch (for example, CHKDSK /F). You'll then be asked if you want to "Convert lost chains to files? Y/N." If you choose the Y option, CHKDSK will turn the lost clusters into files with a .CHK extension. At this point, you haven't gained anything in the way of extra disk space, just the opportunity to look at the lost clusters if you wish. To open up the disk space (about 6M in the example above), you have to choose the N option *before* you choose Y or delete the .CHK files afterward. ■

By Ted Needleman

Microcomputer Musings

Troubleshooting *Windows* Problems and Helping Kids Learn to Read Well

I'm really ambivalent about *Windows*. On the one hand, I love it. I love the applications that are available and the way that the GUI (Graphical User Interface) jump-starts productivity. Mind you, you can be just as productive with a DOS application or one on a mainframe, for that matter. But both the *Windows* and the Macintosh interfaces get you up to a higher level of productivity more rapidly. In my mind, this is the real value of using *Windows*.

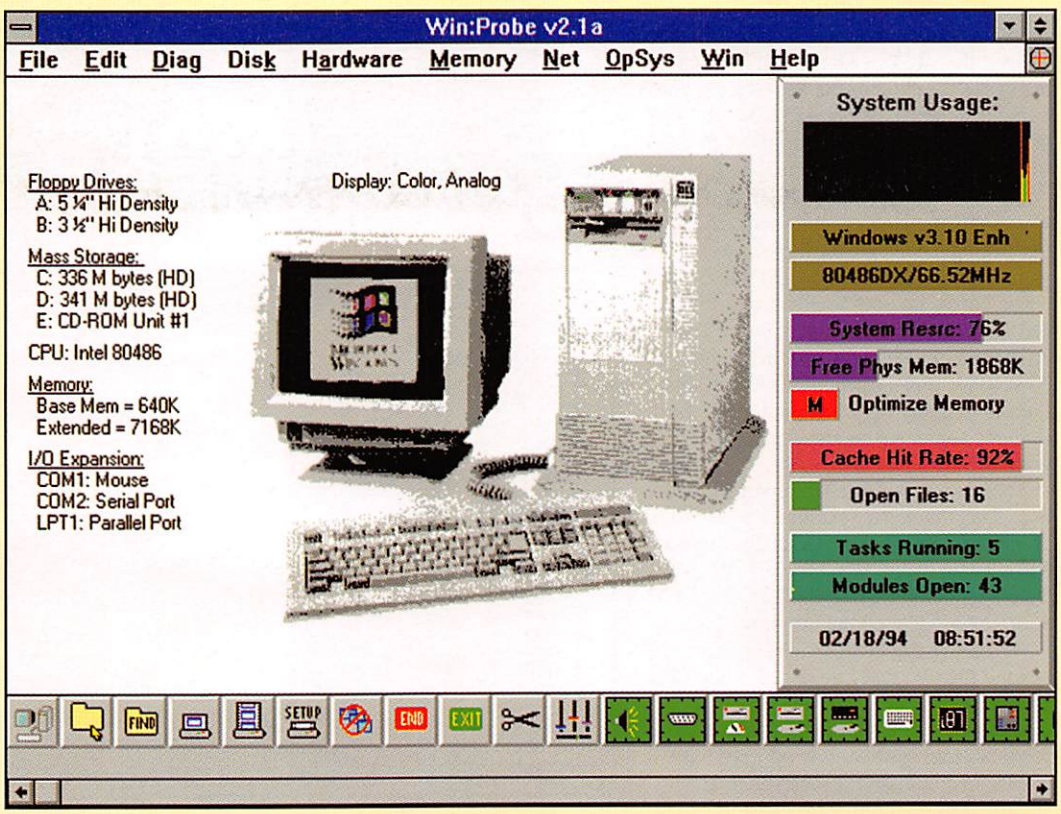
On the other hand, though, when something doesn't work right in or with the *Windows* environment, it's frequently a real bear to fix. *Windows* is a very complex set of interlocking programs and files. If the right portions aren't loaded when they're supposed to be, or if one segment of *Windows* can't find another part where it's expected, you've got big trouble. Add in interrupts, DMA channels and device drivers, and you're set to live in interesting times.

There are a number of utilities that can help in troubleshooting *Windows* problems, but the one I seem to be using most in recent months is a new entry—*WINprobe* from Landmark Research International Inc. Landmark's been around for quite a number of years. Old timers will remember the Landmark Speed Test. For a while, before everyone started developing their own benchmarks, this was one of the most-frequently quoted measures of performance. Landmark has just come out with a new version that's fabulous—the *Landmark Speed Test For Windows* 3.0!

Technicians and troubleshooters are also familiar with Landmark. They bought SuperSoft's *Service Diagnostics* product a number of years ago, and market other popular troubleshooting products like the KickStart board.

WINprobe can be used to help zero in on the cause of a problem or, more likely, to optimize your *Windows* setup. When you run *WINprobe*, you're presented with a picture screen of a PC that gives gross system information, such as amount of installed RAM, number and types of hard and floppy disk types and capacities, CD-ROM and audio card (if installed) and type of video monitor and video available. A comprehensive button bar that runs the length of the bottom of the window can be used to access the rest of the functions, as can the pull-down menus at the top of the window. By clicking on the proper icon (or menu choice), you can test just about any component of your PC, from hard disk to the unit's RAM chips. You can even test the PC's printer and COM ports.

What I really like about *WINprobe* are its Installation Wizard and Tune-Ups. Installation Wizard is a simple report that tells you which IRQs, memory ad-



This *WINrobe* screen shows hardware status of computer.

dresses and DMAs are free and which are being used (and for what devices.) By running Installation Wizard while I'm configuring a new peripheral, I can immediately set the device to avoid conflicts. The convenience of not having to continuously open the PC's system unit to try different IRQs and DMAs makes *WINprobe* worthwhile all by itself. I also really like the software's "Tune-Ups."

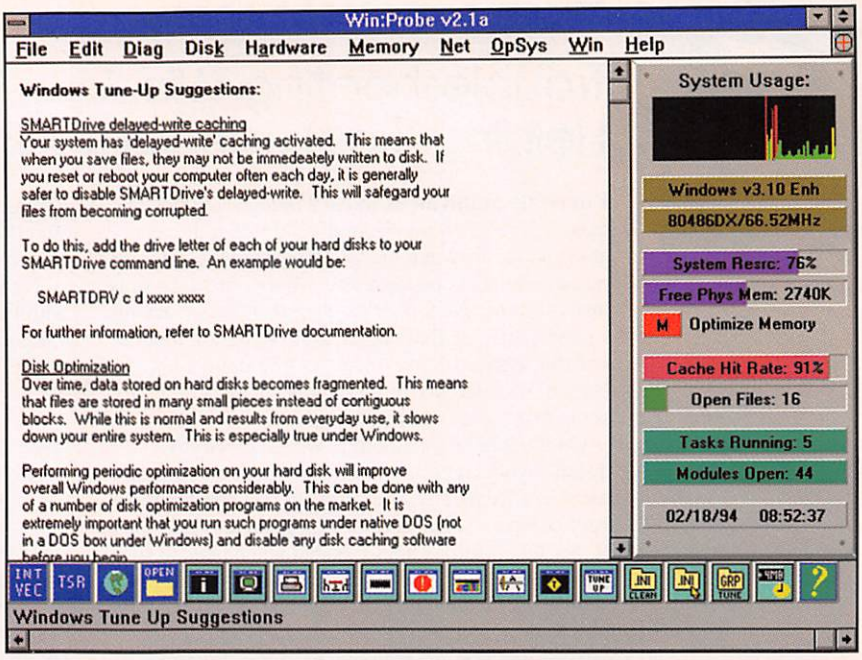
WINprobe's Tune-Ups are a set of reports, displayed on-screen or printed to the *Windows* print device, that tell you what changes can be made to the SYSTEM.INI and WIN.INI files to improve performance. In my case, it advised me to turn off SMARTDRIVE's delayed-write caching (a very good idea, by the way) by inserting the drive letters of my hard disks in the SMARTDRIVE command line. It also advised me to optimize my hard disk and change a number of SYSTEM.INI variables. Since it indicated that these last two changes would probably not do much for overall performance, I disregarded this particular bit of advice.

Running Tune-Up on my WIN.INI file was an eye-opener. There were two pages of references to files that no longer resided on my hard disk. This is a major problem with *Windows* applications in that when you delete an application from your disk, there can be numerous references to the now-defunct application in various .INI files. Printing out the report made it possible for me to delete now-obsolete file references. One thing I noticed that *WINprobe* doesn't do is check the FONTS section of the WIN.INI file for duplicate entries. My greatest improvement came from going through the truly humongous list of *TrueType* files and pruning those I never use. Keep in mind that many applications automatically install fonts, even if you'll never use them. Having them in WIN.INI's FONT list doesn't slow up your applications, but it certainly can slow up your *Windows* start-up procedure. Mine dropped from almost 20 seconds down to about 5 seconds when I cleaned up my FONT list and made the changes suggested by the Tune-Up reports.

There's also a Tune-Up report for GRP lists. This diagnostic examines each program group you've created and tells you where programs no longer exist. You can have an icon in the program group long after you've deleted the program.

WINprobe has lots of nice features beyond the two that I've detailed here. For example, a click on the Memory Optimization button returns memory to *Windows* that applications may not have released when they finished running.

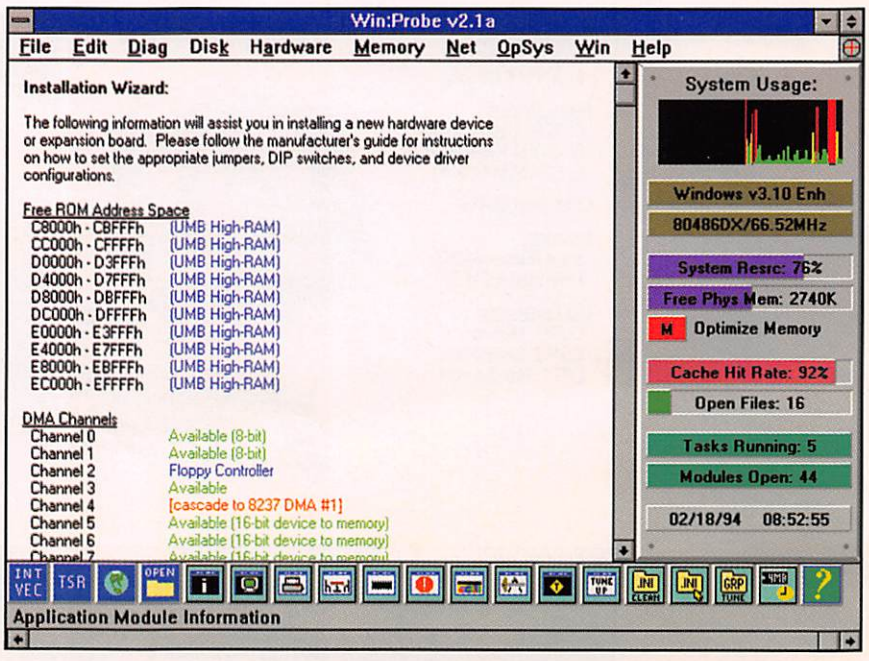
Landmark includes two additional software products in the box when you buy



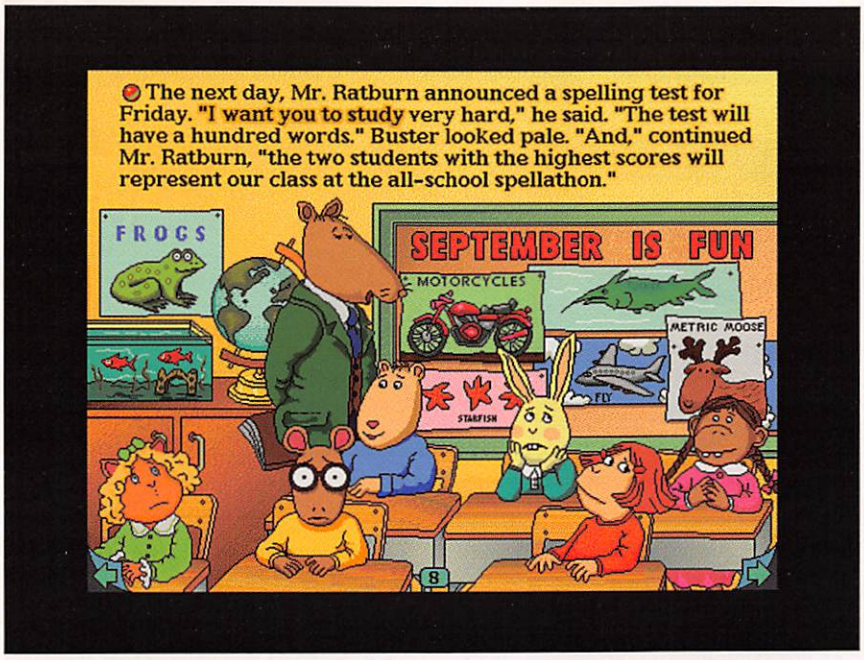
WINNprobe's Windows Tune-up Suggestions screen's hints on how to optimize *Windows*.

WINprobe. PC Certify is a similar utility that runs under DOS. Obviously, it doesn't give you *Windows*-related information like the Tune-Up reports or Memory Optimization. But for diagnosing hardware problems, it's just as useful. More so actually, if you're not primarily a *Windows* user.

The third product in the bundle is Landmark *DOS For Windows*. *DOS For Windows* is kind of a strange product to me. It gives you a fully scale-able DOS window that lets you run DOS programs and execute all DOS commands from within *Windows*. It's a bit nicer to use than the MS-DOS shell that *Windows* itself provides but not so much that I've bothered to let it stay on my hard disk. If you're basically a DOS user, you're not going to spend a lot of time shelling out of *Windows* into DOS. You just won't load *Windows* until you want to run a *Windows* application. Maybe I'm just missing the point with this program.



Installation Wizard is a simple IRQs, memory-address and DMA status report.



Arthur's Teacher Trouble from Broderbund is a CD-Rom story from a children's book

All told, I think Landmark has a winner in *WINprobe*. For $99, it's already saved me more time in troubleshooting device conflicts than my company would have had to pay me to sit on the phone with several technical-support people. That's why we buy these utilities, and it's always nice when they prove their worth.

Reading is FUNdimental

Yep, it's almost here. Summertime! Cookouts, vacations, sunburns and, if you have them, kids finished with school until September. If they're anything like my four, they spend the first two weeks in heaven and the rest of the summer whining about not having anything to do. You could ship them off to camp, of course, but if they do spend the summer at home, why not let them use your multimedia-equipped PC to build and improve an essential skill and, at the same time, have a ball doing it?

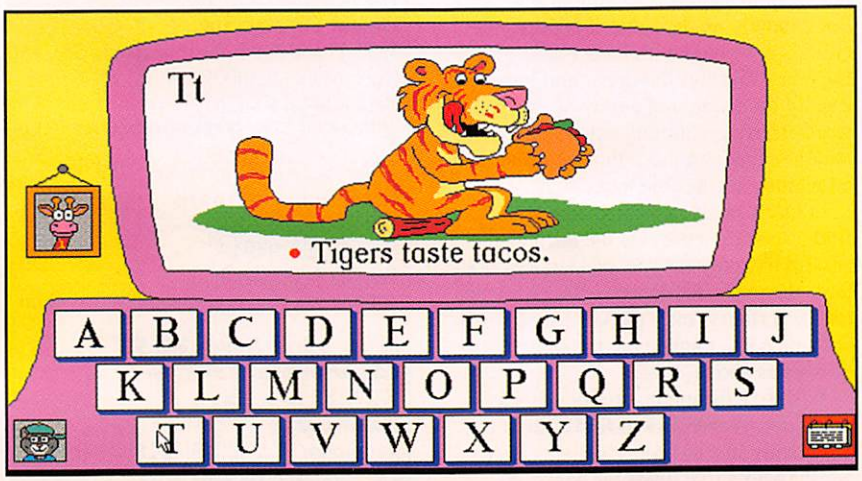
The skill I'm talking about is reading. While I'm not an educator, as a parent, I feel that the ability to read and do it well is just about the most-important skill any of us ever learns. It permits us to communicate with people who aren't physically present or, for that matter, may not even be alive. Of course the fact that this form of communication isn't interactive limits it somewhat when compared to chatting face to face or over the phone, but the written word is still an extremely effective way to convey information (as demonstrated by your reading this column).

I'm a voracious reader, and to be honest, pretty undiscriminating in what I read. Classics, trashy novel, science fiction, murder mysteries, junk mail...it doesn't matter, I read them all. But until I watched my kids struggling with learning to read, I'd forgotten how difficult a process learning how to read well really is. If you stop to think about it, reading involves pattern recognition and memorizing words, discrete analysis (phonetically sounding out words letter by letter) and the understanding of the myriad rules that govern the exceptions. With all that has to take place, it's not surprising that Johnny has difficulty learning to read. It's amazing that he ever does.

The right software can help a lot with this difficult task. My three youngest (7, 7 and 5 years of age) have been working with a number of programs recently that I think you'll find to be really helpful if you have or know of kids who are just starting to read. They all qualify in my mind as "multimedia" in that they make good use of both visuals and sound. All three require at least a 386 PC with a sound card to really be effective. Two of these, Broderbund's *Arthur's Teacher Trouble* and Digital Theater's *The Reading Carnival* are on CD-ROMs and require at least an MPC Level 1-compliant system (single-speed CD-ROM drive). The third, Edmark's *Bailey's Book House*, is a floppy-disk-based program. At the most basic level, all three use a similar approach. They all allow the child to read along with the activity, sounding out the words and then letting the computer "read" it to them.

A beginning reader can just let the computer read the story to him, which is a good way for him to start recognizing words. The exact way these techniques are implemented, and the extent of other activities that each product offers, is where the products vary from each other.

The most traditional "book" is Broderbund's. In some ways, it's the most charming. Broderbund was one of the first companies to embrace this technology, and Marc Brown's *Arthur's Teacher Trouble* is one of the company's Living Books series of CD-ROM-based adaptations of popular children's books. Arthur (who is a mouse) is selected to participate in the school-wide spelling bee by his fifth-grade teacher, Mr. Ratburn. This surprises everyone, including Arthur, and the way he handles this challenge forms the basis for this charming story. The Living Book can be played in English or Spanish, and you can have the PC read the story to you (the words appear on the page, just as with a paper book) or you can go through the story page-by-page interactively, clicking on objects and characters. Clicking on the text has the PC "read" it, while clicking on objects frequently results in



Bailey's Book House from Edmark is aimed at a slightly younger audience.

unexpected actions. Characters, as well, may make a comment or movement when clicked on.

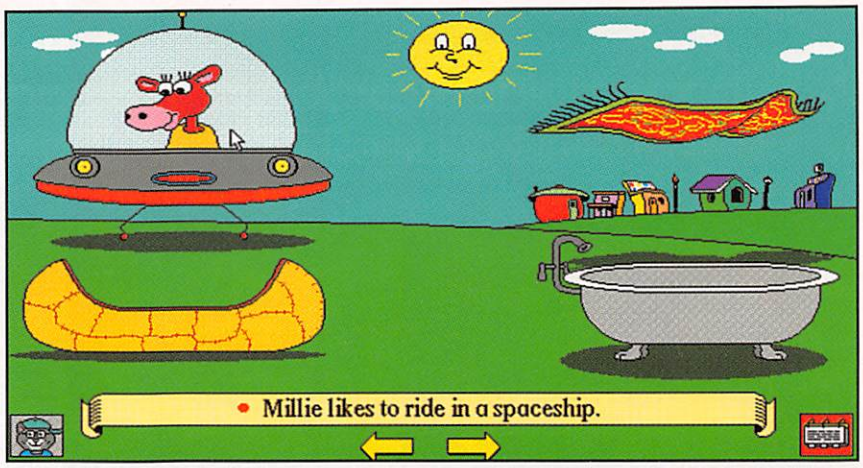
My five-year-old daughter absolutely loves *Arthur*. It's become her favorite "book". She also likes playing with Edmark's *Bailey's Book House*. On the other hand, my seven-year-old twins prefer Digital Theater's *The Reading Carnival*.

The Reading Carnival has six shorter stories, including several Superhero stories like *Bold Beaver* (it's a lot cuter than it sounds—Bold Beaver and his friends save the dam), which can be used either interactively, clicking on areas of the screen, or by letting the PC read to you. None of the stories is quite as engrossing as Broderbund's *Arthur*, but in addition to the stories, there are a lot of other activities. There are animal games that let you click around the screen to find Hot Spots, digitized animal photos, and even spelling games that challenge your child to make words from the letters of various animal names. My kids hate doing this when they get it assigned as homework at school (and they do get assignments that are very similar to these "games"), but they somehow really enjoy the exact same process when it's a computer "game."

The most frequently used feature of *The Reading Carnival* in my house is the coloring book. These screens are based on the stories and other activities and provide a set of outlines and rudimentary drawing and painting tools. The twins' PC is hooked up to a color DeskJet printer, and they just love to come over with their latest "masterpieces."

My one small criticism of *The Reading Carnival* is the music that plays during the short interval while a new screen loads. Don't get me wrong, it's a very bouncy and upbeat tune, and I liked it a lot. At least I did the first 30 or 40 times I heard it. But listening to the same eight or 10 bars for hours on end drove me to the point of screaming "Close your door!" at the kids. I'd think that it wouldn't be all that difficult to have a number of tunes alternate. There's plenty of room on the CD-ROM disc. To be fair, though, the repetition doesn't seem to bother Bryan and Scott in the slightest. It's a bit scary to see them pretty much ignore something that I find extremely annoying, but it does serve to explain why I frequently have to tell them the same thing a dozen times or so before they do it. At least I now *know* it's not just me!

The third product of the group, Edmark's *Bailey's Book House*, is aimed at a slightly younger audience. Edmark has labeled this product "Reading Skills For Ages 2 to 6 Years." I doubt that many two-year-olds are going to operate this program on their own, but I think they'll love watching mommy or daddy clicking on the activities. *Bailey's* consists of a number of discrete activities, each of which operates in either a free-wheeling "explore-and-discover" interactive mode or a more-directed Q&A mode. The activities, accessed through the main menu (which is really a picture of Bailey the Bear's living room) include The Letter Machine, Edmo & Houdini, Read-A-Rhyme, Kid's Cards and Make-A-Story. Each of these presents elementary reading and letter-acquisition skills in slightly different ways.



A screen from Digital Theater's *The Reading Carnival*.

For instance, the Make-A-Story section, reached by clicking on the bookshelf in Bailey's living room, takes your child screen by screen, presenting him with choices that result in a customized story, which can then be printed out. In the first screen you choose the character, the second lets you choose a vehicle, then a place to travel to, and so on. As you click on the different objects, the computer displays the words or names that correspond to them and pronounces the words.

Other sections have different activities but work in a somewhat similar manner. For example, in the Letter Machine, the child is presented with a keyboard. Pressing a key displays the upper and lower case of the letter, and a sentence with words starting with this letter is displayed and then read out loud. Finally, an animated picture finishes the letter.

In Q&A mode, a giraffe asks you to find a specific letter. On the third unsuccessful try, only the row of keys that contains the requested letter is displayed. After the forth try, only the key asked for is shown. When clicked on, the screen progresses as above.

With five different activities, it's a cinch that your kids will find at least one they really like in *Bailey's Book House*. Karin, who's five, likes the Make-A-Story, Letter Machine and Kids Cards. The last lets them make a variety of simple greeting cards.

The software industry has coined a new term, "Edutainment," for this kind of software. Software that entertains as it teaches may have a new name, but it isn't really that new a phenomenon. Apple Computer, along with Tandy and Commodore, were all largely built around software similar in concept, if somewhat cruder in execution.

The true test of software, at least in my house, is whether or not the kids go back to it more than a few times. Not every kid loves every product or activity, but as a group, my hoard loves all three of these packages. And that's about the best recommendation a father can get or give. ■

Products Mentioned

WINprobe, $99
Landmark Research Int'l., Inc.
703 Grand Central St.
Clearwater, FL 34616
Tel.: 800-683-6696
CIRCLE NO. 131 ON FREE INFORMATION CARD

The Reading Carnival, $49.95
Digital Theater, Inc.
5875 Peachtree Industrial Blvd., Ste. 150
Norcross, GA 300092
Tel.: 800-344-8426
CIRCLE NO. 132 ON FREE INFORMATION CARD

Arthur's Teacher Troubles, $39.95
Broderbund Software
500 Redwood Blvd.
Novato, CA 94948
Tel.: 415-382-4600
CIRCLE NO. 133 ON FREE INFORMATION CARD

Bailey's Book House, $49.95
Edmark Corp.
6727 185 Ave. NE
PO Box 3218
Redmond, WA 98073-3218
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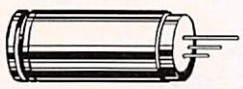
Collimator Pen



Output: 2.5 mW (max.); Current 90-150 mA
Oper. Volt: 2.2-2.5 V; Wl: 820 nm - Infrared
Size: 11 mm dia. x 27 mm L; Data sheet inc.

Stock#	1-9	10-24	25+
SB1052	49.99	47.49	42.74

Collimating Lens

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Stock#	1-9	10-24	25+
LSLENS	24.99	23.74	21.37

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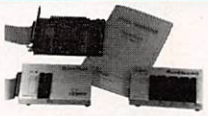

Programs all EPROMS, EEPROMS, including flash memories. Programs microcontrollers with optional adapters. Complete with software, programming module, cable & manual. Single Device programming.

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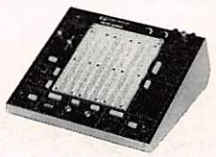

Stock#	1-9	10-24	25+
PB503	299.99	284.99	256.49

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LS9200	Toshiba	670nm	3 mW	39.99	37.99	34.19
LS9211	Toshiba	670nm	5 mW	59.99	56.99	51.29
LS9215	Toshiba	670nm	10 mW	109.99	104.49	94.04
LS022	Sharp	780nm	5 mW	13.99	13.29	11.96
SB1053	Phillips	820nm	10 mW	10.99	10.44	9.40

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MV961	79.99	75.99	68.39
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CIRCLE NO. 105 ON FREE INFORMATION CARD

By Tom Benford

A 3D Surround-Sound Audio Card With Wavetable Synthesis for Less Than $300 and a Sampling of Multimedia CD-ROM Titles

There are so many interesting and exciting things happening in multimedia that it's difficult to keep track of it all. For example, the trend in sound-card design is definitely leaning towards wavetable synthesis, rather than being FM-based. Even Yamaha is jumping on the bandwagon with its OPL4 chipset, which combines FM- and wavetable-based sound. This being the case, I'll start this column by taking a look at a wavetable-based card that has good sound, a rich assortment of unique features and an affordable price tag.

Sound Card

Alpha Systems Labs' $299 Cyber Audio/SRS sound card made its debut at COMDEX in November 1993 and attracted lots of attention for a number of reasons. The card features 3D surround-sound, utilizes wavetable synthesis, is General MIDI-compliant and has an integrated digital signal processor. Among other features—which include extensive voice-recognition capabilities and SoundBlaster and AdLib compatibility—these make it quite a package for under $300 suggested retail.

This three-quarters-length card requires a 16-bit slot for installation. Mounted on the card is a daughterboard that contains the SRS chip and support circuitry that endows the Cyber Audio/SRS with its uniquely spatial "surround-sound" capabilities. In effect, what this does is give the sound increased audio ambiance so that it seems to be coming at you from all directions, rather than just the left and right speakers.

I was skeptical of this capability until I spent some time experimenting with different placement settings that permit the user to locate the source of the sound anywhere in the room he desires. The thing that impressed me most about this surround-sound effect is that I still got the same 3D effect even if I changed position with relation to the speakers. I could walk around without losing the stereo effect. This increased ambiance really adds to the realism of simulations, games and multimedia applications that incorporate sound effects and music.

Even with the SRS daughterboard in place, the Cyber Audio fits within the width of one expansion slot on a PC bus and shouldn't interfere with any adjacent boards in most installations. According to ASL, the components of the daughterboard are being integrated into the main sound card. So the models available by the time you read this should be a single-stage unit that's devoid of the daughterboard. All of the same features and functionality will be retained. For older cards, the SRS feature will be an optional upgrade chip retailing for about $50. Essentially, the base card will carry a $249 suggested list. So adding the surround-sound capabilities will bring the price up to $299 suggested retail.

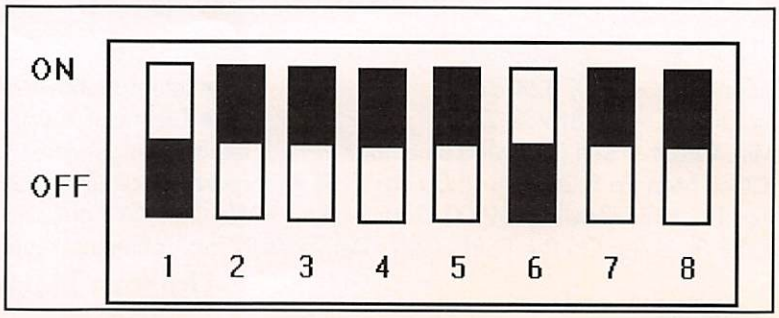
Installing the SRS upgrade will be like adding a math coprocessor to your PC's motherboard. You merely plug the SRS chip into the socket provided for it on the main card.

Cyber Audio/SRS's input/output options are quite good. Stereo miniature phone jacks are provided on the mounting bracket to accommodate external audio input, audio output, auxiliary/CD audio input and a dual-purpose 15-pin D-shell joystick/MIDI connector. An internal four-pin connector is also provided on the board for accommodating CD audio, and a 50-pin SCSI connector is integrated into the Cyber Audio/SRS. The well-written user's manual notes that since the internal CD audio input is connected to the auxiliary connector, one or the other—but not both—should be used.

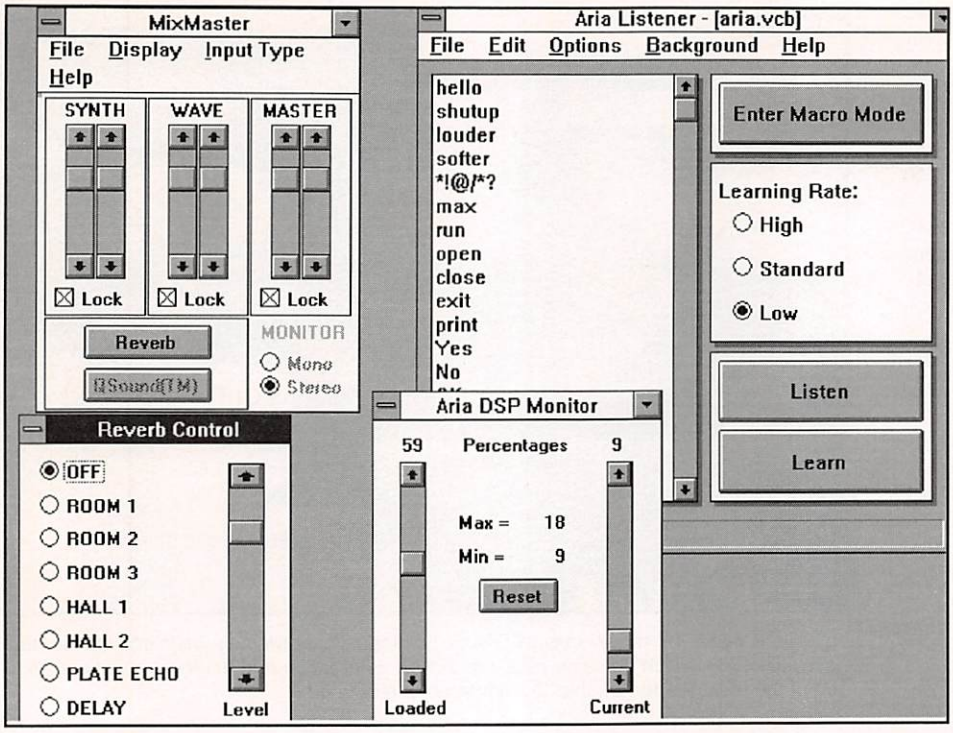
Other components on the main card include a DSP (digital signal processor) chip, an Adaptec SCSI controller chip, an audio control chip that handles the direct-memory-access (DMA) functions and 1M sound ROMs in which the wavetable samples are stored.

Jumpers and DIP-switch blocks are provided for changing the hardware configuration settings from the factory defaults, although the defaults should work without a problem in most cases. The factory default configuration for interrupts are:

IRQ5	Sound Blaster Emulation
IRQ2	MIDI Interface
IRQ10	Aria Digital Audio System
IRQ12	SCSI Interface



Factory default DIP-switch settings of the Alpha Systems Lab Cyber Audio/SRS audio card. This switch block and four jumper blocks provide a good range of configuration options to overcome conflicts with other installed peripheral devices.



Cyber Audio/SRS's utility applications include: the Mixer applet (upper-left) that contains a Reverb button that launches the Reverb Control applet shown below it. The Aria Listener applet (upper-right) is used for "training" the card and creating new voice-recognition vocabularies, and the Aria DSP Monitor permits adjusting recognition thresholds and related settings for the card.

Default I/O ports are:

220H	Sound Blaster Emulation Base Port
290H	Aria Base Port
330H	MIDI Base Port
340H	SCSI Base Port

DMA channel defaults are:

CH 1	Sound Blaster Emulation
CH 2	Aria System

Other miscellaneous defaults include:

AdLib Decode	Enabled
Joystick Port	Enabled
Joystick Speed	Normal

Since, by default, the joystick port is enabled, it may present a conflict with a joystick port that exists on another card in your system. Disabling either the Cyber's joystick port or the port on the other card will resolve the conflict.

Jumpers are provided for user selection of the interrupt and DMA channels for the Aria digital audio system, Sound Blaster emulation, MIDI interface and SCSI interface. Four small jumper blocks with header caps are provided for changing these settings.

An eight-position DIP-switch block is also located on the card for changing additional configuration settings. Here's a summary of the switch defaults and their optional settings (factory defaults for the card as shipped are shown in bold):

DIP Switch 1 and 2—Aria Base Port Address:

SW1	SW2		
OFF	OFF	=	280h
ON	**OFF**	=	**290h**
OFF	ON	=	2A0h
ON	ON	=	2B0h

DIP Switch 3—SoundBlaster Base Port Address:

ON = 230h **OFF = 220h**

DIP Switch 4—MIDI Base Port Address:

ON = 320h **OFF = 330h**

DIP Switch 5—AdLib Base Port Address 388h Decode:

ON = disabled **OFF = enabled**

DIP Switch 6—Joystick Port:

ON = enabled OFF = disabled

DIP Switch 7—Joystick Speed:

ON = fast **OFF = normal**

DIP Switch 8—SCSI Base Port:

ON = 140h **OFF = 340h**

No special skills or procedures are required to install the card. Since the default settings will generally work in the vast majority of instances, all that's required is for you to plug the card into an available 16-bit PC expansion slot and make some I/O connections (CD-ROM audio output, speakers, CD-ROM interface, etc.). Once you've done this, you install the software. Software installation is a highly automated task that you can complete in just a few minutes, especially if you use all the default values.

In addition to Voyetra's *AudioStation* software, Cyber Audio/SRS also comes with *Voice Macro* software. This application is a voice-recognition package that enables the PC to respond to your spoken commands in DOS games (provided they're Aria-aware, or engineered to recognize and use the Aria chip's capabilities) and *Windows* 3.1 and *Windows* applications.

Voice Macro is fairly sophisticated in its speaker-independence. It's able to correctly recognize spoken commands in the vast majority of instances, regardless of your vocal quality or rate of speech. While it isn't infallible, it does work much better than I expected it to and better than some of the third-party voice-recognition packages currently available. This is a very nice extra feature that's included at no additional cost. The system is capable of understanding 125-word vocabularies. An unlimited number of vocabularies can be stored and loaded, as required.

The on-board Aria synthesizer can play 32 stereo voices simultaneously in eight amplitude-envelope states. The synthesizer is General MIDI-compliant and has 128 instrument samples stored in its 1M of ROM. Though no ROM expansion is possible with this card, the stored samples are quite good and should be more than adequate for the majority of users. Sound quality is certainly light years ahead of FM-based music synthesis.

Cyber Audio/SRS is capable of recording and playing back one track of stereo or two tracks of monophonic sound in recording and playback sampling rates of 11, 22 and 44 kHz. The card isn't capable of 16-bit resolution, but eight- and 12-bit resolution rates are supported. This is important to note if you need 44-kHz, 16-bit sampling for your work (such as in prepping Redbook audio tracks for CD mastering or DAT recording). If you aren't going

to be performing tasks like these, the 12-bit resolution will prove to be more than satisfactory in most cases.

This card also supports ADPCM (adaptive differential pulse code modulation) compression of up to 4:1 ratio at a 22-kHz sampling rate to keep sound quality high while conserving disk space.

Mixer application provided with this card can handle three stereo and six monophonic channels, and 256 volume-level control settings are possible per channel. Since all audio volume adjustments are software-controlled, no mechanical adjustment control is provided on the card or its bracket.

The surround-sound feature is really unique and works incredibly well. The other feature I think is really neat is the Cyber Audio/SRS's DSP capabilities, with reverb functions taking the spotlight in particular. You can add reverb in varying amounts and depths to any sound played through the card, .WAV as well and MIDI files included. The reverb effects are variable from room ambiance through concert hall through multi-plate delays for echo effects.

Cyber Audio/SRS delivers an exceptionally rich assortment of features, capabilities and very good sound for a very affordable price. I found it to be an excellent value all around.

New Multimedia CD-ROMs

The multimedia snowball continues to pick up momentum, and the flood of CD-ROM-based multimedia software is approaching deluge proportions. The following are some of the really outstanding ti- tles that have come my way since the last issue.

• ***Midnight Movie Madness with Gilbert Gottfried*** (Medio Multimedia, Inc., $59.95). With a voice like fingernails dragging across a blackboard, late-night cable-TV personality Gilbert Gottfried is the host of this disc, which contains "trailers" of what may well be the worst horror/sci-fi/cult movies ever produced. This disc is one of three titles in Medio's Explorer collection, which also includes the *JFK Assassination: A Visual Investigation* and *Exploring Ancient Architecture*.

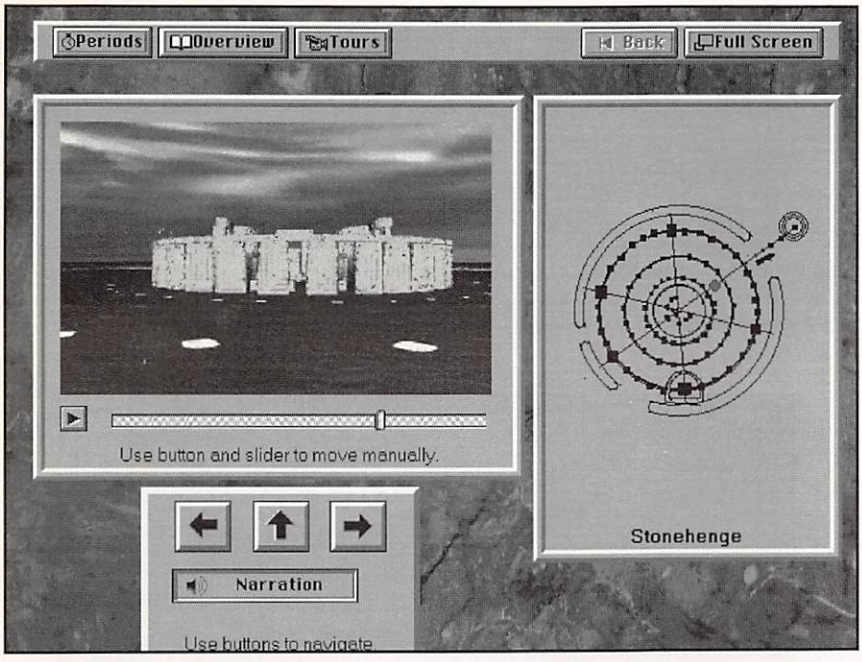
To give you an idea of what's on this disc, see if you can summon up childhood memories of catching the Saturday afternoon matinee as a kid to view such celluloid classics as: *Queen of Outer Space* (1958), starring Zsa Zsa Gabor; *The Screaming Skull* (1958), which provided free burial for anyone in the audience who died of fright (an impossibility) watching it; *Destroy All Monsters* (1968), a Japanese offering starring Godzilla *et al*; *Plan 9 From Outer Space* (1959) with Bela Lugosi, Tor Johnson and other cronies of *cinema noir* director Edward D. Wood; *Conqueror Worm* staring my favorite villain, Vincent Price; and scores of others, including *The Blob, King Kong Versus Godzilla* and *One Million Years B.C.*

Late-night cable TV movie maven Gilbert Gottfried hosts *Medio's Midnight Movie Madness* CD-ROM, which contains cast, production information and full-motion video clips of 100 of the most (un)forgettable "B" movies ever produced.

In all, this disc contains more than 40 minutes of full-motion video-clip memorabilia comprised of trailers, intermission commercials, comedy quizzes and little-known facts about these movies. The opening video sequence is an irritatingly humorous introduction by Gottfried, and the disc is hosted by a greased-back '56 rock-'n-roller known as "The Spirit of the Drive-In," who also provides comic relief throughout the disc. The quizzes and trivia were written by a pair of former editors of *National Lampoon,* and they're pointed and witty.

This disc is so different, so novel, so entertaining and so full of bad-movie nos-

Medio's *JFK Assassination: A Visual Investigation* is the most-complete information resource on this tragic event compiled to date. In addition to animation, multiple video clips and a wealth of still photographs and diagrams, the complete text of the Warren Commission Report and the book *Crossfire* are also included in their entirety on this disc.



With *Exploring Ancient Architecture*, you can take a stroll through Stonehenge and see it as the ancient Druids did during the Neolithic period. Egyptian, Greek and Roman architecture are also represented, and you can depart from the programmed "tours" to explore and study items of interest as you desire. All of the architecture is presented as it was when first constructed, rather than as the ruins and rubble of its present state.

talgia that it's an absolute must-have for any cinema buff and for general reference purposes. Pop it into your CD-ROM drive, grab some popcorn and remember what it was like when movies cost less than $10 million (less than $100,000 in some cases) to produce in yesteryear.

• ***JFK Assassination: A Visual Investigation*** (Medio Multimedia, Inc., $59.95). Another title in Medio's Explorer Collection, this disc takes a serious and highly focused look at what is, without doubt, one of the most shocking and controversial events of this century. In addition to text, photos and audio segments, it contains full-motion video of the infamous 8-mm Zapruder film and other home-movie footage shot on November 22, 1963. Precise computer animations that clearly show conflicting bullet angles and the complete text of the *Warren Commission Report*, as well as the book *Crossfire*, make this the *de-facto* reference work on this dark day in recent American history.

The 8-mm home movie shot by Abraham Zapruder with his Bell & Howell camera that captured the actual assassination on film is included. This clip can be viewed at normal and slowed speed and frame-by-frame. Three other home movies (the Nix, Hughes and Muchmore films) are also included to show different points of view of this infamous event. An assortment of still photos, including the "magic" bullet and actual morgue photos of JFK's corpse, as well as autopsy diagrams, interviews, local newspaper coverage and much more, are all included in this exceptionally well-researched and well-produced CD-ROM. If you're looking for the most complete reference on this subject available, this disc is unquestionably it.

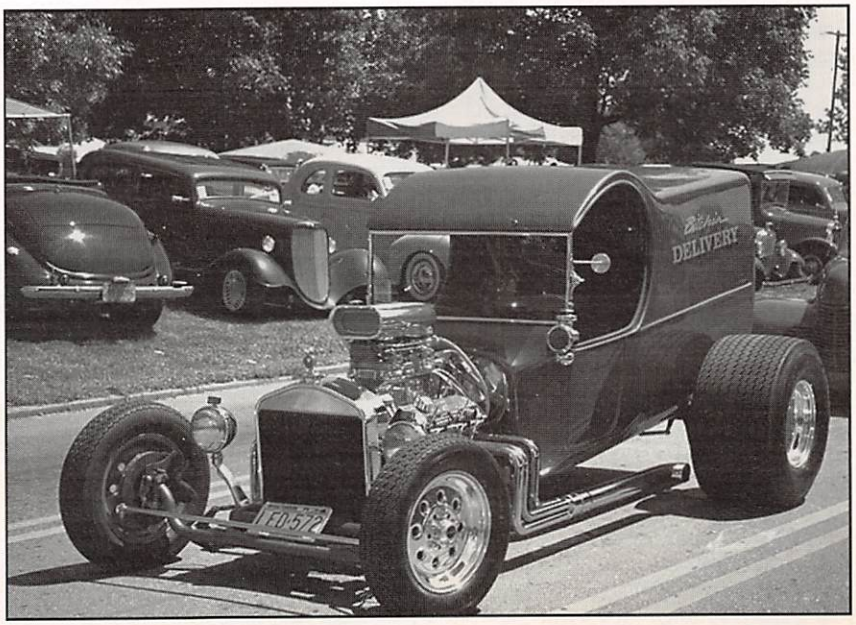
• ***Exploring Ancient Architecture*** (Medio Multimedia, Inc., $59.95). The third title in Medio's Explorer Collection, this disc, will appeal to history and architecture buffs and anyone who has ever wondered how many ancient civilizations were able to erect their enormous structures without modern construction equipment.

The feature I liked best about this disc is that it let me actually walk through the buildings and structures that now stand in ruins, but my view of them was as they were originally. The colors, lighting and artifacts are seen as they were when the edifices were first built. You can stop, look around and walk in any direction to examine the interiors and exteriors of the buildings, and the 3D detail is excellent. While you're exploring, you can listen to a narrative that explains the surroundings.

The full-motion video is composed of outstanding renderings done by award-winning architectural animator Andrew McClary. Dr. Bruce Meyer, professor of architecture at Ball State University, did the historical and structural content. Included in the program are comprehensive multimedia presentations about each of the time periods, the people and their cultures.

This disc is an excellent example of what multimedia can be used for. I found it to be very educational and highly entertaining—perhaps "fascinating" is a better word—at the same time.

• ***American Street Rods Photo CD-ROM*** (John O'Connor Publishing Ltd., $99.95). Because this disc is in the Kodak Photo-CD format, you'll need a CD-ROM drive that complies with the XA (extended arch-



One of the 100 custom cars and trucks on the *American Street Rods Photo CD-ROM*. This is a Kodak Photo-CD-format disc that requires an XA-compliant CD-ROM drive to view.

itecture) specifications to read it. As with other Photo-CD discs, you can also view it with a Philips CD-I player, Kodak Photo-CD player or other device that's capable of reading the XA format as well.

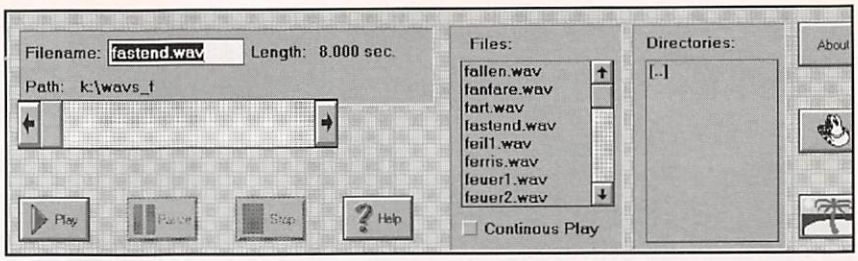
If you're into cars, street rods in particular, this disc is really going to be your cup of tea. One hundred of the best street rods and custom trucks were professionally photographed at the 24th Annual Street Rod Nationals in Columbus, Ohio, and these photos are the content of the disc.

Image quality is pristine, and customs from mild to wild are represented. Royalty-free usage rights are provided for non-commercial applications, and extended usage rights for commercial purposes can be obtained at reasonable rates. If custom cars are your thing, check out this disc.

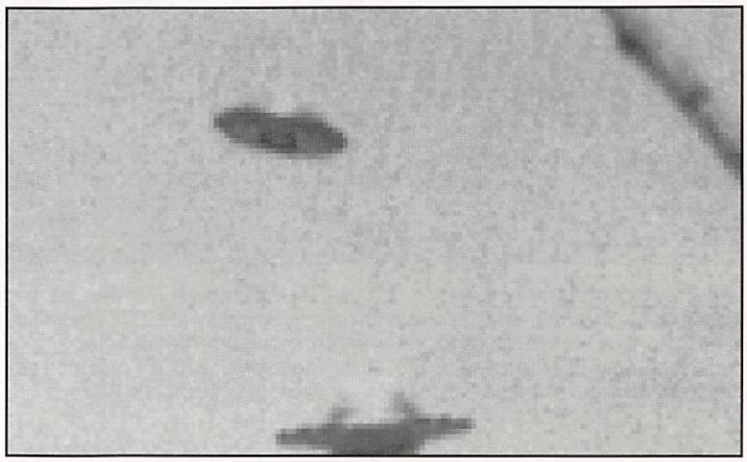
• ***999+ .WAV Files for Windows*** (John O'Connor Publishing Ltd., $19.95). One of 13 new low-priced ($19.95) CD-ROM titles in the Tropical Series from John O'Connor Publishing, this disc is a collection of .WAV sound files that range the gamut from body noises to clips and quips, from movies and TV shows to sound effects to animal sounds to musical snippets to...well, you get the idea. As its name implies, there are more than 999 .WAV formats on this CD-ROM—lots more. In fact, there are more than 1,500 sound files in total, and they're all in the .WAV format for use in *Windows*.

As you can imagine, auditioning all of these files can take a considerable amount of time and would be a laborious and tedious process if you were to do it from the Media Player accessory that comes supplied with *Windows*. Fortunately, the CD-ROM contains a utility applet called the *TidalWAV Sound Player* that makes auditioning the files a snap. This utility installs directly in *Windows* in just a few seconds. Once installed, you can browse the disc to hear such audio pearls as "fat, drunk and stupid is no way to go through life, son" (from *Animal House*); "as always, if you or any of your IM force should be caught or killed, the secretary will disavow any knowledge of your actions" (from *Mission Impossible*); Bullwinkle the Moose saying "hello out there in TV land;" and hundreds of other sound bytes. With a suggested retail price of $19.95, this is the best and least-expensive collection of .WAV files I've found to date. It's sure to add some fun to using *Windows*.

• ***UFO—This Planet's Most Complete Guide to Close Encounters*** (Software Marketing Corp., $59.95). If you're one of the people who believe that we aren't alone and this planet is the destination of alien visitors, this disc is definitely one you'll want in your CD-ROM library. It presents the world's largest collection of UFO photographs in the popular .PCX format for easy copying and viewing. More than 1,200 descriptive accounts of sightings spanning more than 3,000 years are also included, and you can view specific sightings and UFO events, including contact and abduction reports.



The *TidalWave Sound Player utility* included on the *999+ .WAV Files for Windows* CD-ROM makes the disc's more than 1,500 sound files easier to audition. The disc is chock full of audio pearls and is one of the best under-$20 CD-ROMs available.



These two saucer-shaped UFOs appear in one of the numerous still photos on the UFO disc. Scores of full-motion video clips, maps and sighting accounts make this disc invaluable for anyone interested in the subject of unidentified flying objects.

The program's interface is very easy to use, permitting you to select sightings by a number of parameters, such as photographic or motion-picture evidence, abduction, death, injury and psychic involvement, mutilations and much more. Most of the full-motion video clips have either narration or actual event sound tracks, including some ear-splitting UFO motor sounds.

Whether or not you believe in extra-terrestrial visitation, this disc is certainly well-produced, exhaustively documented and thoroughly entertaining. If you're a UFO-ologist, you will find it to be indispensable. ■

Companies Mentioned

Alpha Systems Lab (ASL)
2361 McGaw Ave.
Irvine, CA 92714
Tel.: 714-252-0117

CIRCLE NO. 161 ON FREE INFORMATION CARD

John O'Connor Publishing Ltd.
188 Fries Mill Rd. F-3
Turnersville, NJ 08012-2021
Tel.: 609-875-8897

CIRCLE NO. 162 ON FREE INFORMATION CARD

Medio Multimedia, Inc.
2703 152 Ave. N.E.
Redmond, WA 98052
Tel.: 206-867-5500

CIRCLE NO. 163 ON FREE INFORMATION CARD

Software Marketing Corp.
9830 S. 51 St., Bldg. A-131
Phoenix, AZ 05044
Tel.: 602-893-3377

CIRCLE NO. 164 ON FREE INFORMATION CARD

By Yacco

GUI Guts

Where is the GUI Going?

It wasn't long ago that most PC users pooh-poohed the graphical interface, or GUI, for it's consumption of memory, storage, and processor cycles. Some still do, but today the GUI interface is finally getting the respect it deserves. A majority of users have come to accept that the trade-off in greater productivity is well worth the cost of upgrading hardware. In the final equation, a small increase in fixed costs is far outweighed by the long-term savings of expensive man-hours, and as the price of increasingly hot basic computers has continued to fall, this equation has become an overwhelming factor for the vast majority of business applications.

Now, nearly every software vendor is developing a *Windows* version of its product line. Exceptions can be broadly lumped into two categories. One is simple recreational software that places a greater emphasis on speed of execution than on ease of use. Most games aren't rich enough in options to benefit from menus, drag and drop and other GUI features, and users are basically killing time with them, anyway. Responsive play is the most-important factor.

Samsung's Finale 8000 Laser printers offer a host of functions starting at about $2000.

The other category is composed of applications that have their own graphical interface. By and large, these are graphics products, and some are already similar to *Windows* in such important characteristics as menus and the use of pointing devices.

Business productivity applications typically don't fall into either of these categories, and they're nearly all available in a *Windows* version (or have one on the way). The benefits of *Windows* are growing as a consequence of this widespread conversion. Printing is one example. Prior to *Windows*, there was just one widely available high-level page-description language (PDL): PostScript. The lack of competition allowed prices to remain high, and quality printers were expensive. The other widespread page-description option was Hewlett-Packard's PCL. It's presence in the less-expensive, and virtually ubiquitous, HP LaserJet printers made it popular, but it wasn't nearly as powerful as PostScript. In both cases, software had to be written to support the particular PDL.

Under *Windows*, applications only need to interface to the environment. The printer vendor interfaces to *Windows* and the software is automatically supported. And printer vendors are taking advantage of this superior level of support to offer less-expensive printers with more features.

Samsung Finale 8000

Samsung's inexpensive Finale printer line is a good example. It offers several emulations, including PostScript, PCL5, IBM Proprinter XL/24 and Epson FX-850 emulation. It also includes PCL5's HPGL/2 commands, but they're enhanced by the polygon commands from Hewlett-Packard's 7550 plotter. Hewlett-Packard PCL5 printers support only 7475A plotter commands, which lack polygon support. *Windows* helps Samsung in resolution, speed and WYSIWYG ease-of-use. Finale models are extremely-high-resolution printers. Ordinary 600 x 600 printers may produce only 51 shades at 600 dpi, or they may produce as many as 91 grays, but only by reducing their resolution to 300 x 300 dpi. Much higher resolution is necessary to produce the additional shades that create photo-realistic images. For instance, you're probably used to seeing 256 shades of gray on your monitor. The Finale has an ability to print 256 shades of gray in each of its dots. In some cases, the quality of Finale printers nearly rivals professional print shops.

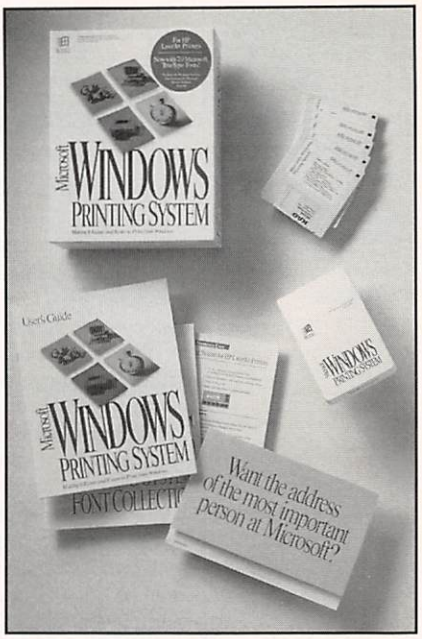
Samsung calls the method used to achieve it's high resolution, with an inexpensive printing engine, HighResolution Halftone Technology. Basically, Finale printers electronically image a number of dots into each quadrant of each dot that the printer's engine can mechanically address—300 x 300 in the HiRes and 1012 models. Even the toner is special, and its dots are too fine to see clearly without magnification. This permits these printers to offer 72-,

83-, 106- and 150-line-per-inch (lpi) screens with an effective resolution up to nearly 2,000 dpi. It's incredibly detailed and has near-photographic quality. The Finale line provides this quality at prices beginning about $2,000, which is a small fraction of an image setter's price and far less than the $9,000 you might pay for some awkward printer solutions that require an imaging card in your workstation.

The *TrueType* rasterizer included in Samsung's Finale line gives these printers one other advantage over older printer technologies. That's the ability to directly print the *Windows* 3.1 *TrueType* fonts as *TrueType* fonts. It permits direct use of *Windows* fonts without the up-to-30% performance hit that can occur when *Windows* converts its fonts for other printers. Without such a rasterizer, *Windows* automatically converts its fonts to the Type I format before downloading them to a printer. So, the fonts displayed on the video monitor's screen aren't precisely like those that appear on the printed page. In other words, printers that lack this support aren't quite true WYSIWYG in nature.

Finale printers use the Intel i960 RISC processor. In one model, the 1012, Samsung speeds things along by using the latest Intel 4.0 i960 compiler to create firmware that runs the chip faster. The company claims that this pushes the unit's 16-MHz. i960KA RISC processor to the performance levels of a 20-MHz. i960KA run with the old compiler code. The combination of its features gives the 1012 the ability to print complex pages at nearly its full rated engine speed.

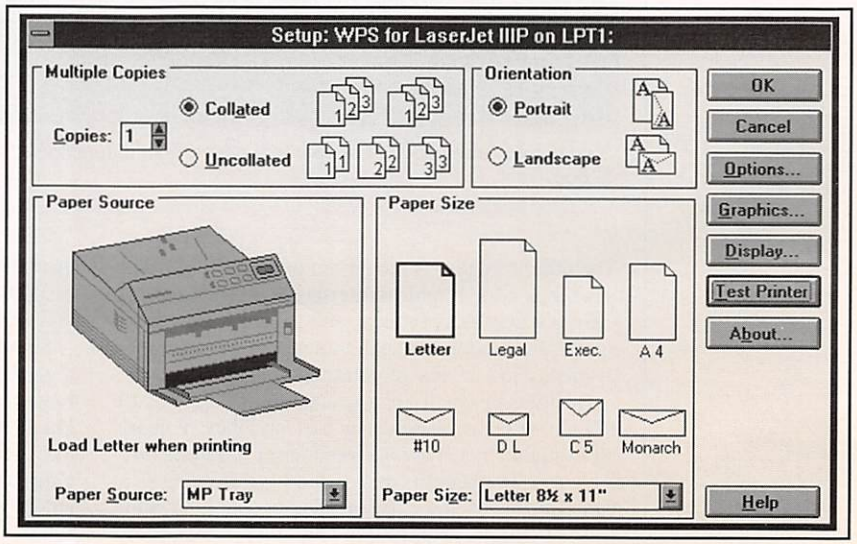
These printers also have enough memory that they can build pages themselves. instead of requiring the host to do the job.



Microsoft's Windows Printing System includes a hardware module for Hewlett Packard Laser Jet II and III laser printers.

Six-million words of memory are required to produce full-pages at high resolution, and every byte of it is standard in these printers. Moreover, printer memory is expandable to 18M bytes for the purpose of holding documents in the printer while their images are processed. As a consequence, a Finale printer frees the host computer from a lot of computation, and it can even be used on a small network without overloading it with huge bitmap traffic.

Samsung expects to further enhance its Finale line with a 1212 model, a 12-ppm printer with higher-quality output, at Spring Comdex this year. The 1212 will



Windows Printing System main screen from which you control all printing options.

be based on a 600 X 600 X 4 engine that will produce an effective 2,400 X 2,400-dpi resolution. It's expected to have built-in network fax support as well.

Microsoft Printing System

Microsoft has also used *Windows* GDI technology to improve the performance of older printers. The Microsoft Printing System includes a hardware module that works with Hewlett-Packard LaserJet II and III printers. The LaserJet IV has built-in bidirectional printing and works with the Printing System's software engine. Either way, the system eliminates translation between the *Windows* GDI and PCL. It's *Windows* talking to *Windows*. The system is transparent when printing from a DOS application.

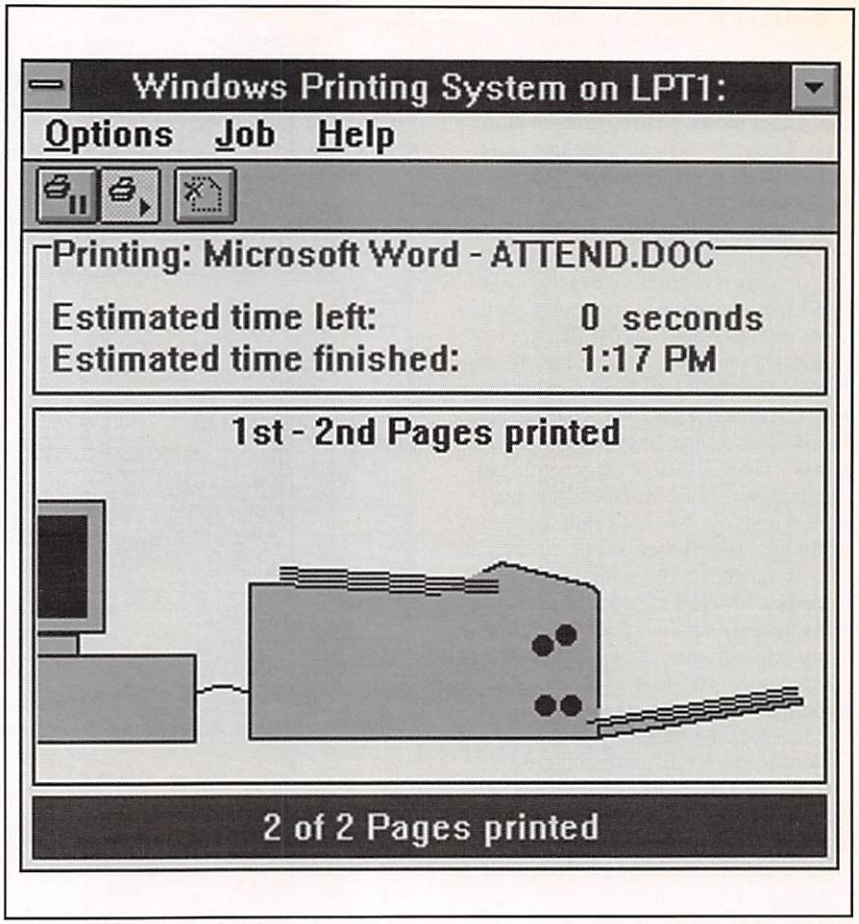
The Printing System offers a simple plug-and-go design that automatically detects printer resources. You simply plug the module into the printer's font slot, and it works with the software engine. The product comes with *TrueType* fonts, and it provides bidirectional printing. The system also reports job status, estimated time to job completion and hardware status such as low toner, out of paper, paper jam, cover open, etc.

The Microsoft Printing System is based on a core Resource Based Printing (RBP) technology, a banding technique that prints in lines, rather than fully-composed pages. With load balancing, it can split work between the printer and CPU and steal cycles when *Windows* is idle. Both the Printing System and Finale use a GDI model, and just as they're by the *TrueType* engine in a Finale printer, the *TrueType* fonts produced by the *Windows* GDI are displayed the same on the printer.

The Next Step

While *Windows* has been a boon, it's far from the be-all and end-all of personal computing. In fact, the graphical user interface is ultimately too limiting for the way humans work. As good as point-and-click is, a pointing device (even one developed specifically for *Windows* like the Kensington Expert Mouse 4.0) requires you to take your hands off the keyboard to use it. And even a great pointer that works from the home row (like the one on the new IBM ThinkPad portables) is still connected to a keyboard and requires typing skills not everyone possesses. We'd really like to have our computers work with us the way we've evolved to work over millions of years—with speech and intelligence.

The ultimate interface would work much the same way people communicate with each other. To this end, IBM has already made a leap in speech capabilities with a new continuous-speech-recognition system for it's current offering to OS/2 developers. Like other continuous-speech-recognition systems, the IBM technology will allow applications to recognize speech, not merely individual words, without artificial breaks in it utterance. In addition, the new system reportedly has a superior ability to recognize words without significant training and without retraining for differences that occur with colds or even between users.



Windows Printing Systems status screen gives page and time progress reports.

With Verbex's Listen for Windows, you communicate by voice with your PC.

While you're waiting for IBM to release a *Windows* version of its technology, and for that to appear in new products, you can add continuous-speech recognition with a product like *Listen for Windows*. *Listen for Windows* includes a 16-bit ISA adapter card with a high-speed digital signal processor (DSP) and directional headset microphone for hands-free use. Speech interfaces for 24 programs, including the Program Manager, Norton Desktop and a number of popular applications, such as *AutoCAD for Windows*, *Microsoft Office*, *Lotus Smart Suite*, *WordPerfect*, *CorelDRAW*, the *Windows* accessories, Asymetrix *Compel*, *Quicken* and Maxis *SimCity* and *SimAnt* simulation games. There are 10 or so general commands as well, such as Open File, that work with most *Windows* applications. A minimum 80386 processor is required in your computer for use with this card.

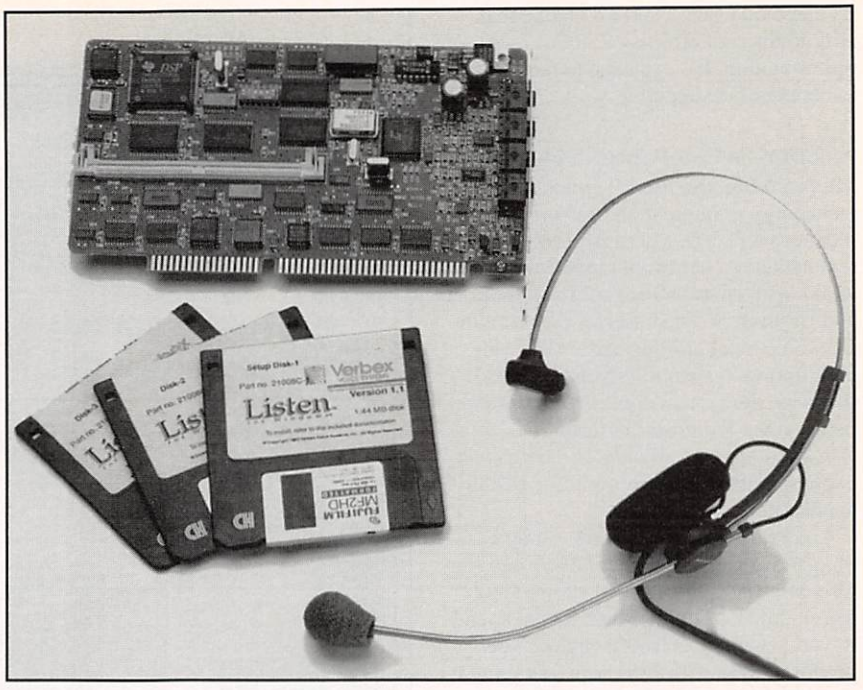
Verbex also just announced a low-cost software-only version of the product that requires you to provide a sound card and microphone. A 66-MHz. 486 processor is recommended for use with this version. It also includes the same 24 application interfaces as the hardware-based product.

If you're a developer, there's a also a version for you that has more memory for faster processing. The developer version includes additional software that produces speech response from high-quality compressed speech files (not synthesis). You can use it to customize the product's interface, as well as to replace complex sequences of commands—even involving multiple applications—with your own simple commands. There are no royalties and applications, except speech response, will run with any version of the product. Speech response requires the card-level product. The card is also recommended for *AutoCAD*, as is a fast processor.

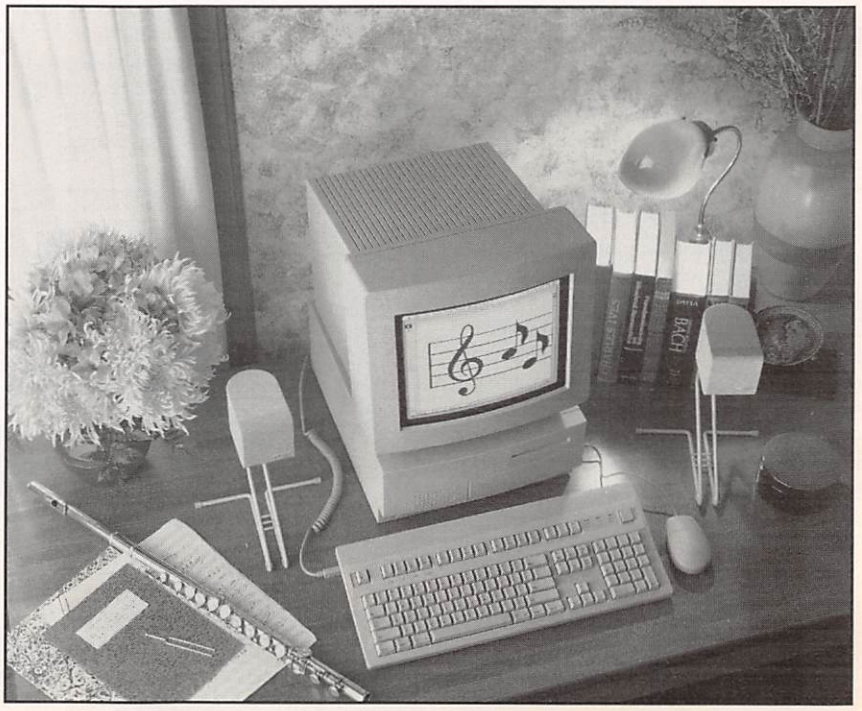
As much as voice recognition can improve productivity by reducing multiple levels of menus to a single utterance, it's still not the ultimate interface. Verbex includes both an on-screen list and a printed quick reference card to help you with the verbal commands that replace your keystrokes. Consider that there are over 400 commands in the *AutoCAD* interface, and you can see why they're necessary.

What the interface of the future must do is replace the current lists of fixed commands with intelligence. It must be able to understand a variety of expressions, extract their meaning, apply that meaning to the context of suitable applications and execute the appropriate functions. This is probably a little more than the average person can do on a regular basis—but, hey, what are computers for anyway?

Would the ability to conduct an intelligent conversation with our computers then provide the ultimate interface? It would certainly be getting close, but there's still one more element to consider: those all-important esthetics. Just as *Windows* improved your productivity by adding color and graphical elements, such as buttons and icons, so we would like to leap beyond *Windows*—perhaps to an interface that jumps off the screen into three-dimensional space via holography. At the very least, a superior interface must let you follow the progress of your commands with photorealistic animations. And one of them just may be that of an anthropomor-



Verbex offers a "talk-to-your-PC" interface system in its hardware/software Listen for Windows package. A software-only version is available if you already have a Sound card.



Base's powered Acoustimoss-3 speaker system consists of a floor-mounted bass unit and two compact satellite units.

Products Mentioned

Bose Accoustimass-3, $699
Bose Corp.
The Mountain
Framingham, MA 01701-9168
Tel.: 800-444-2673

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Microsoft Printing System, $199
Microsoft Corp.
One Microsoft Way
Redmond, WA 98052
Tel.: 800-426-9400

CIRCLE NO. 146 ON FREE INFORMATION CARD

Finale HiRes, $2,086 (8 ppm); Finale 1012, $2,495 (10 ppm); 1012 Ethernet option, $349 (Estimated); 1012 Tokenring option, $249 (Estimated)
Samsung Printing & Storage Systems
105 Challenger Rd.
Ridgefield Park, NJ 07660-0510
Tel.: 800-524-1302 or 201-229-4000

CIRCLE NO. 147 ON FREE INFORMATION CARD

Listen for Windows 1.2, $399 (DSP, 1/2M); *Listen for Windows* 1.2 $99 (Software Only, 66-MHz i486 recommended, sound card and microphone required); *Listen for Windows Developer's Kit* $695 (DSP, 1M and compressed speech-response software)
Verbex Voice Systems, Inc.
1090 King George Post Rd.
Edison, NJ 08837
Tel.: 800-275-8729

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phic helper convincingly mouthing the words your computer speaks. Will such a system be a mere device or a new form of intelligent life? This may just end up being a question for the courts of the future to decide.

Zounds! It's Ver Bose

If you do opt for the developer's kit and its voice-response capabilities, or if you simply seek the best possible sound output for your CD-ROM, consider the Bose Powered Accoustimass-3 Speaker System. Its twin speakers and separate bass unit can fill a fairly large room with the richest sounds your computer can produce. They'll handle multimedia applications, too, from an action-packed presentation to a videophone conference.

The floor mounted Accoutimass bass unit includes the unit's amplifier, and the system's satellite speaker cubes are so small that you can mount them just about anywhere. Bose offers two varieties of stands you can use with the cubes, a short style that's suitable for desktop mounting and a much taller one for floor mounting. Of course, you can simply rest these speakers on any convenient stand or shelf or even hang them on a wall.

As a speaker system designed for use around noisy computer electronics, the Accoustimass-3 system obviously features shielding from radio-frequency interference. It also features Bose's patented Dynamic Equalization circuitry that matches bass reproduction to highs across the full range of volume. This permits the speakers to reproduce sounds the same way, whether you have the volume turned up for a large group or down for a private demonstration. Moreover, once you adjust your treble and bass controls for the acoustic properties of a room, Dynamic Equalization eliminates the need to readjust them when volume is raised or lowered. The latest version of the system even allows you to simultaneously hook up the sound from your computer and your CD-ROM outputs to separate inputs. The required isolation is provided in the Accoustimass' circuits. It's just the kind of set-it-and-forget, trouble-free operation you need to help you concentrate on your application, instead of having to become an audio expert. ■

Tuning Up Your Computer *(from page 75)*

Up window and select Properties. Then click on the Run Minimized check box.

If you choose to have DOS applications run minimized, *Windows* doesn't actually run them when it starts. Instead, it places an icon for each onto the desktop. But they're poised there, ready to go and waiting only to be selected and run.

Don't worry about the time required to start the programs when you enter *Windows*. I have two *Windows* applications and four DOS applications in my StartUp group. It takes *Windows* less than 5 seconds to prepare them all each time it starts. If instead I start each one manually when I enter *Windows*, I have to spend at least a couple of minutes doing so.

Final Remarks

When your computer is completely tuned, make sure you make copies of the configuration files. At the very least, you should keep copies of your CONFIG.SYS, AUTOEXEC.BAT, WIN.INI and SYSTEM.INI files in a safe place. The next time you install a new application, it will probably try to change at least one of these files. If you have previous copies, you can examine the differences between the new and old files to help you decide whether or not you want to keep the changes.

Fine tuning your computer can be a challenge. The *Windows Resource Kit*, which you can order from Microsoft, or a program like SoftLogic Solutions' *WinSense* can be a great help in understanding all the possible settings in WIN.INI and SYSTEM.INI. Once you've tuned up your computer, it's a lot easier to keep it in-tune than it is for your car. And like a well-tuned car, your computer will respond to your work by running faster and smoother. ■

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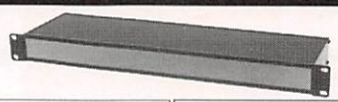

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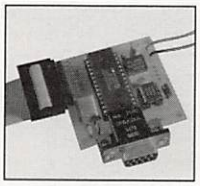

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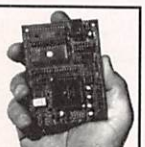

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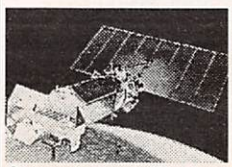

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Manufactuer	Model	Modem/Fax Speed*
AMP	PCMCIA Fax/Modem	14,4K/14.4K
	PCMCIA Fax/Modem	9,600/9,600
Angia	FAX14442 PCMCIA	14.4K/14.4K
AT&T	3760 "TeekInTouch" Cards	14.4K/14.4K
	3761 Series	9,600/9,600
Dr. Neuhaus	Fury Card 2400	2,400/9,600
	Fury Card 14K4	14.4K/14.4K
COM Plus	PCM42LC	2,400/9,600
Communicate	Connexion 2496	2,400/9,600
E-Tech	C9G24MX	2,400/9,600
Exar	2400/9600 Fax/Data Modem	2,400/9,600
EXP	ThinFax9624 Fax/Data Modem	2,400/9,600
DataRace	V3.2/BF	9,600/9,600
IBM	2.4/9.6 Data/Fax	2,400/9,600
	14.4/1.4 Data/Fax	14.4K/14.4K
Intel	2400+/INC110	2,400/9,600
	FAX9600	9,600/9,600
	INC30	14.4K/9,600
Iwatsu	Data-Fax Modem	9,600/9,600
Librex	Fax+Modem	9,600/9,600
Megahertz	CC3144	14.4K/9,600
	CC324FM	2,400/9,600
	X11144	14.4K/14.4K
	XJ124FM	2,400/9,600
Omnitel	Business Card 2496C	2,400/9,600
P.N.B.	PNB24	2,400/9,600
	PNB144	14.4K/14.4K
RCS	XM2496	2,400/9,600
Socket Communications	SL700	9,600/9,600
Smart Modular	SmartTalk 9624	2,400/9,600
TDK	DF2496A	2,400/9,600
	DF1414A	14.4K/14.4K
Texas Instruments	MBH10218	9,600/9,600

* Maximum in bps.

Table 4. PCMCIA Network-Card Buying Guide

Manufacturer	Model	Type
AMP	10-Base-T LAN Adapter	Ethernet
D-Link	DE-650	Ethernet
DataRace	RediCard LAN Adapter	Ethernet
IBM	Token-Ring 14/4	Token Ring
MagicRam	Ethernet Adapter	Ethernet
National Semiconductor	Ethernet	Ethernet
Socket Communications	EA + Ethernet	Ethernet
Xircom	PCMCIA CE-102 BNC/CE-10BT	Ethernet

Classified Commerial Rates: $1 per word, 15-word minimun ($15.00) prepaid. (Word count includes name and address; Zip code and abbreviation each count as one word; P.O. Box number and telephone number count as two words each.) Indicate free category heading (Computers, Software, Electronics, Video or Miscellaneous). A special heading is avaliable for a $6 surcharge. First word only is set boldface caps at no charge. Add 25¢ for each additional boldface word.
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ROMY-16 EPROM Emulator emulates 2716-27010 ROMs or 6116-628128 RAMs in 8-and 16-bit systems. Provides eight hardware breakpoints for 8-bit systems. **$195**(2716-27256) or **$245**(2716-27010). Optional assembler, disassembler, and ROM debugger for $100 each CPU. **Universal Microprocessor Simulator/Debugger V2.1** simulates popular 8-bit microprocessor. Assembler, Disassembler, windowed symbolic Simulator/Debugger. $100 each CPU. **80C552 Development System $190.** Eight channel, 10-bit A/D. Watchdog timer, on-chip oscillator, RS-232 serial communication, one 8255A.32K ROM, 64K RAM. $120 each board. optional 40x2 LCD display $20. **80C31 Development System $125.** 8K ROM, 1K RAM, 40x4 LCD display, assembler, disassembler, on-board debugger. RomMax EPROM Programmer $145. ProMax Universal Programmer $450. **J&M** Inc. 83 Seaman Road, West Orange, NJ 07052, Tel: 201-325-1892, Fax: 201-736-4567.

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Multimedia *(from page 78)*

one presentation. For graphic images, it reads *Windows* .BMP, .WMF and .DIB files, *PC Paintbrush* .PCX files, CompuServe's .GIF files, and the old favorite Targa and .TIFF files. For video and animation, it directly reads *Video for Windows* .AVI and Autodesk .FLI and .FLC. For audio, it picks up .WAV and MIDI. This list is surely not the largest, but it's quite adequate for general usage. Besides, it's not hard to get your data into one of the above formats.

A source of additional help for owners of *SST* is included as part of the owner's manual. It's a reference work named *Making Great Presentations On Your PC*, written by two industry professionals. This book teaches practical information on communication technique, multimedia as art of communication and the involved technical aspects of creating a meaningful presentation. This reference, the *SST* tutorial and the product itself comprise a positive step for anyone who wants to author multimedia presentations without spending too much money and too much time on their projects.

Products Mentioned

FileRunner for Windows, $49.95
MBS Technologies, Inc.
4017 Washington Rd., #4000
McMurray, PA 15317
Tel.: 412-941-9076

CIRCLE NO. 155 ON FREE INFORMATION CARD

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Novato, CA 94948-6121
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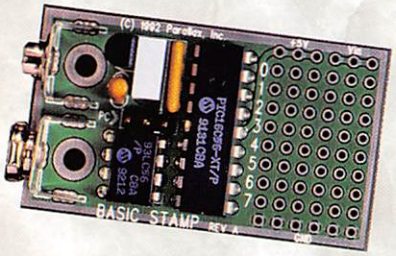
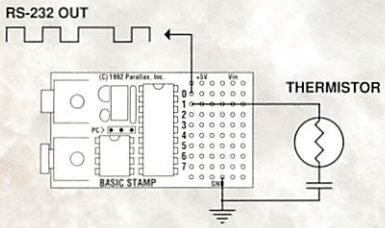


The BASIC Stamp is a 1x2-inch computer that runs BASIC programs written on your PC. It has 8 I/O lines, which can easily be programmed for serial communications, potentiometer input, pulse measurement, button debounce, tone generation, PWM, etc. And all by just adding a resistor and/or capacitor, if anything. Single Stamps sell for $39, and quantity prices start at just four units.



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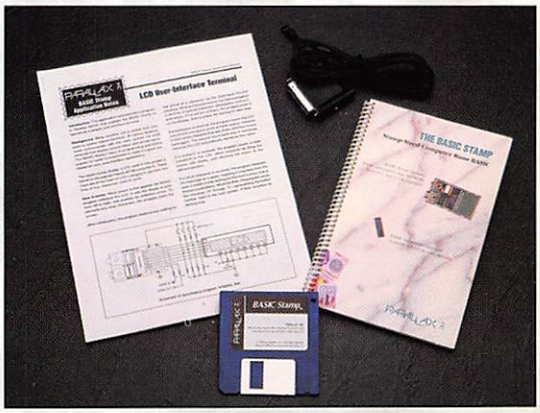

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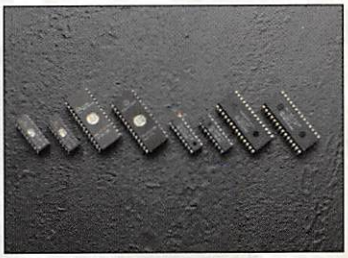

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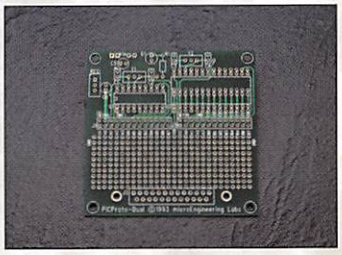

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